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(54) Coding and decoding methods and systems.

(57) Input data is efficiently variable length coded by using a variable length coding table selected from among a plurality of variable length coding tables (23C, 23D) in accordance with a coding efficiency. It is thus possible further to improve variable length coding efficiency as compared with a case using only one variable length coding table. As a result, when generating information content equal to that generated by using only one variable length coding table, it is possible to process quantized data with a smaller quantization size and further to improve the quality of information transmitted as coded data.

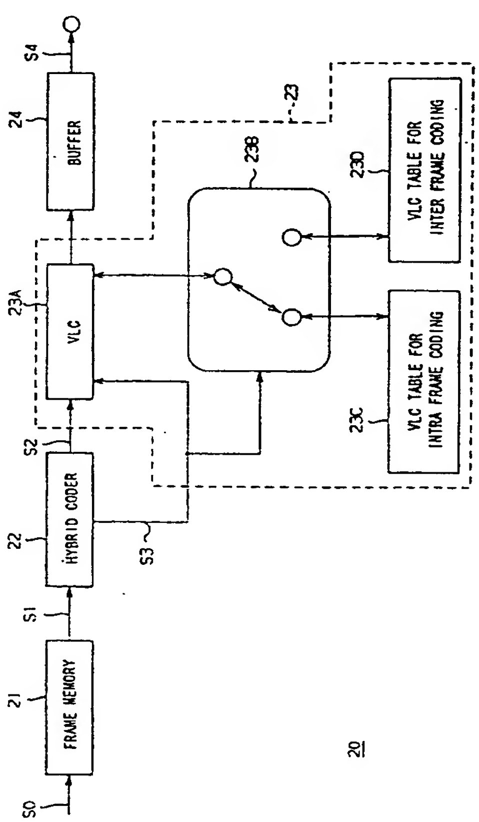

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 8349

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	INTERNATIONAL ORGANISATION FOR STANDARDIZATION - ISO/IEC JTC1/SC2/WG11, 13 November 1991 pages 1 - 74 SOURCE: MATSUSHITA 'MPEG Document 91/217' * page 3, line 1 - line 8 * * section 2.13 on page 13 * ---	1-16	H04N7/13 H04N7/133
X	EP-A-0 469 835 (CANON KABUSHIKI KAISHA) * claims 1,7; figures 5A,5B * ---	1,2,9,10	
X	PATENT ABSTRACTS OF JAPAN vol. 14, no. 553 (E-1010) 7 December 1990 & JP-A-02 237 368 (SHARP CORP.) 19 September 1990 * abstract * ---	1,9	
A	PATENT ABSTRACTS OF JAPAN vol. 16, no. 475 (E-1273) 2 October 1992 & JP-A-04 170 187 (OLYMPUS OPTICAL CO. LTD.) * abstract * ---	1-16	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, vol.38, no.1, February 1992, NEW YORK US pages XVIII - XXXIV G.WALLACE 'The JPEG still picture compression standard' * page XXIII, left column, line 26 - line 36; figures 1,2 * ---	1-16	H04N
P,X	EP-A-0 542 474 (AMERICAN TELEPHONE AND TELEGRAPH COMPANY) * page 7, line 30 - line 39 * * page 15, line 36 - page 16, line 10; figure 10 * -----	1-16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 October 1994	Giannotti, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

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L : document cited for other reasons

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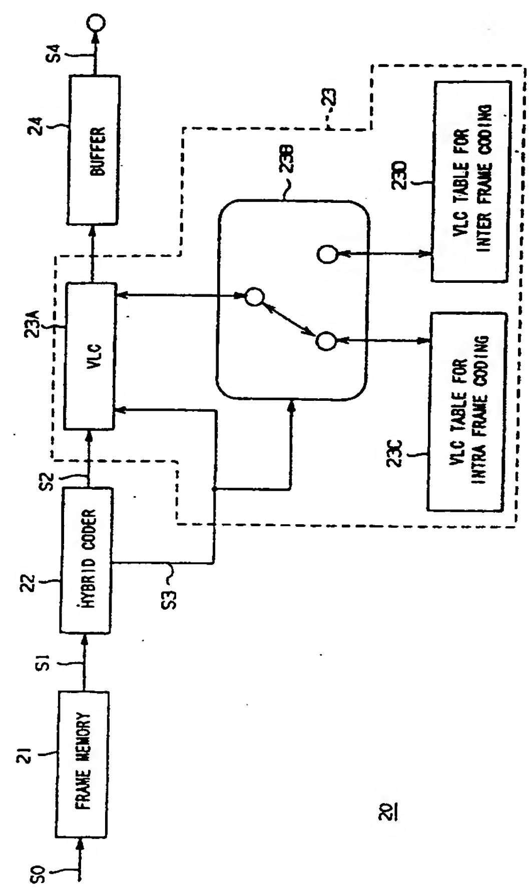

FIG. 5

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This invention relates to coding and decoding methods and systems, and is applicable, for example, to variable length coding and decoding methods and systems for orthogonally transformed picture signals.

Video signal transmission systems for transmitting video signals in the form of motion pictures to remote places, such as a video conference system and videophone, have been proposed. In the video signal transmission systems, video signals are coded by using line correlation and inter frame correlation of a video signal in order efficiently to use a transmission path, thereby improving the transmission efficiency of significant information.

For example, intra frame coding uses the line correlation of video signals. Therefore, as shown in Figs. 1A and 1B, when transmitting pictures PC1, PC2, PC3, ... at time points $t = t_1, t_2, t_3$, ..., constituting motion picture, the picture data to be transmitted is one-dimensionally coded in the same scanning line before transmitting the picture data.

Inter frame coding improves compressibility by using the inter frame correlation of video signals to obtain picture data PC12, PC23, ... having differences in pixel data between successively adjacent pictures PC1 and PC2, PC2 and PC3, ...

Thereby, the video signal transmission system is constituted to code the whole picture data for pictures PC1, PC2, PC3, ..., with high efficiency into digital data of much less quantity than the picture data compared with the case in transmitting the picture data, and send the digital data to a transmission path.

Fig. 2 shows how a picture sequence is intra frame coded or inter frame coded and transformed into three types of frames (macroblock) such as an intra frame predicted frame, forward inter frame predicted frame, and forward, backward, bidirectional inter frame predicted frame. In Fig. 2, 15 frame periods (frames F0 to F14) are used as one unit for coding.

For this example, the frame F2 is intra frame coded and is called "an intra picture". The frames F5, F8, F11, and F14 are predicted only by the frames F2, F5, F8, and F11 located ahead of the above frames respectively, and are called "predicted pictures".

The remaining frames F0, F1, F3, F4, F6, F7, F9, F10, F12, and F13 are predicted by frames located ahead of the above frames, those located behind the above frames, or those located at the both sides of the above frames as well as inter frame coded, and are called "bidirectional pictures".

Fig. 3 shows a video signal transmission system. The video signal transmission system 1 has a coding d vice 1A for transmitting data and a decoding device 1B for receiving coded data.

After the coding device 1A converts an input video signal VD via a preprocessing circuit 2 into a luminance signal SY and color diff r nce signal SC, these are convert d into an 8-bit digital luminance signal DY and color difference signal DC by the analog to digital conversion circuits 3 and 4.

Then, in the coding device 1A the digital luminance signal DY and digital color difference signal DC are written into a luminance signal frame memory 5A and color difference signal frame memory 5B of a frame memory 5, respectively, and thereafter the picture data is transformed from a frame format into a block format in a format conversion circuit 6.

In the coding device 1A the picture data transformed into the block format is input to an encoder 7, and the picture data is high efficiently coded to generate a bit stream which is transmitted to a decoding device 1B via a communication path and a recording media 8.

The encoder 7 is composed of a hybrid coder 7A for discrete cosine transforming the intra frame or inter frame coded (forward, backward, or both way predicted) picture data, and thereafter quantizing the picture data, as well as a variable length coding apparatus 7B for variable length coding and outputting the quantized data.

The decoding device 1B decodes the bit stream taken from the recording media 8 by performing an innersive procedure of the coding device 1A. That is, the decoding device 1B inverse transforms the bit stream high efficiency coded by a decoder 9 so as to restore it, and transforms it from the block format into the frame format in a format transform circuit 10.

Then, in the decoding device 1B the digital luminance signal DY and digital color difference signal DC transformed into the frame format are written into a luminance signal frame memory 11A and a color difference signal frame memory 11B, respectively.

Thereafter, in the decoding device 1B, the above signals are converted into analog signal SY and SC via digital to analog conversion circuits 12 and 13, and the decoding device 1B inputs the signal to a post processing circuit 14 to obtain an output picture and output it as an output video signal VO.

The video signal transmission system 1 is constituted so as to transmit or receive data through a series of the processes.

In this connection, the video signal transmission system 1 processes the data of a frame picture in the unit shown in Figs. 4A to 4C. First, the data for a frame picture is divided into N slices as shown in Fig. 4A. Each slice includes M macroblocks as shown in Fig. 4B and each macroblock includes luminance signal data Y1 to Y4 corresponding to 8 x 8 pixels and color difference data Cb and Cr corresponding to the total pixel data as shown in Fig. 4C.

In this case, th pictur data stream in each slice is arranged so that picture data follows in macroblocks, and also follows in microblocks in each macroblock in order of rast r scanning.

The macroblock uses picture data (Y1 to Y4) for 16 x 16 pixels following in the horizontal and vertical scanning directions for a luminance signal as one unit,

but uses one microblock Cr or Cb assigned to the data for 16 x 16 pixels as an unit, because the data quantity is d creased and thereafter time base multiplexed for two color differenc signals corresponding to the picture data (Y1 to Y4) for 16 x 16 pixels.

For the coding device 1A, only one type of variable length coding (VLC) apparatus 7B of the encoder 7 for high efficiency coding picture data is given as a conversion table (hereinafter referred to as "VLC table") used for variable length coding quantized data independent of the type of picture processed. For the encoder 7 based on MPEG1 (Moving Picture Experts Group 1), for example, the VLC table is constituted in accordance with the quantized data generated through inter frame coding.

However, the result of comparing the quantization data generated by inter frame coding with the quantized data generated by intra frame coding does not always have the same frequency distribution. That is, when considering the quantized data generated by intra frame coding as a macroblock, it is very similar to the quantized data generated by inter frame coding in composition, but a considerably large difference is found between them in the overall composition (or inclination). Therefore, it is estimated that a high efficiency coding cannot be expected merely by directly applying the VLC table prepared corresponding to inter frame coding to the processing of the quantized data generated through intra frame coding.

According to the invention there is provided a coding method for variable length coding quantized input data in predetermined blocks (e.g. in macroblocks), in which input data is variable length coded by using any one of a plurality of given variable length coding tables 23C and 23D which is selected in accordance with the coding efficiency.

Moreover, this invention uses a coding apparatus for variable length coding quantized input data in predetermined blocks (e.g. in macroblocks), the coding apparatus comprising: a plurality of variable length coding tables 23C and 23D assigned with different sign lengths; a coded information generating means 22 for designating the change of variable length coding tables used for variable length coding input data in accordance with a coding efficiency: and a coding means 23A and 23B for variable length coding input data by using any one of the variable length coding tables 23C and 23D, which is selected in accordance with the coded information outputted from the coded information generating means 22.

Furthermore, this invention uses a decoding m thod for variable length decoding coded data inputted by a r cording m dium or transmission path in pred termin d blocks (e.g. in macroblocks), in which a variable l ngth coding table identical to the variable length coding tabl 23C or 23D used when cod d data is generated is selected among a plurality of given variable length coding tables 32C and 32D and coded data is variable length decoded by using the variable length coding table 32C or 32D.

Furthermore, this invention uses a decoding apparatus for variable length decoding coded data inputted through a recording medium or transmission path in predetermined blocks (e.g. in macroblocks), the decoding apparatus comprising: a plurality of variable length coding tables 32C and 32D assigned to different sign lengths; a switching means 32B for selecting a variable length coding table identical to the variable length coding table 23C or 23D used when the coded data is generated is selected among a plurality of variable length coding tables 32C and 32D in accordance with coded information extracted from coded data; and decoding means 32A for variable length decoding coded data by using the variable length coding table 32C or 32D selected by the switching means 32B.

It is possible to further improve the variable length coding efficiency compared with the case in specifying one variable length coding table by using the variable length coding table 23C or 23D selected among a plurality of given variable length coding tables 23C and 23D based on a coding efficiency and variable length coding input data. Upon thereby generating information content identical to the content when specifying one variable length coding table, it is possible to process data quantized in a smaller quantization size and further improve the quality of information to be transmitted as coded data.

It is possible further to improve the variable length coding efficiency by variable length coding input data with a variable length coding table selected in accordance with the coding efficiency among a plurality of variable length coding tables prepared compared with the case for performing variable length coding with only one variable length coding table.

Thereby, when generating the information content equal to that generated by using one variabl length coding table, it is possible to select a smaller quantized size and further improve the quality of the information transmitted as coded data.

Embodiments of the invention described below provide a coding method and system with a higher coding efficiency than conventional ones, and a decoding method and system for decoding the thus-coded data.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which lik parts are designated by like refer nce numerals or charact rs throughout, and in which:

Figs. 1A and 1B are schematic diagrams for explaining inter frame coding;

Fig. 2 is a sch matic diagram showing a picture structure in a picture sequ nce;

Fig. 3 is a block diagram showing a video signal

transmission system;

Figs. 4A to 4C are schematic diagrams showing a hierarchical structure of picture data;

Fig. 5 is a block diagram showing a coding system using the variable length coding according to an embodiment of this invention;

Fig. 6 is a flow chart for explaining a variable length coding procedure;

Fig. 7 is a block diagram showing a hybrid coder;

Fig. 8 is a frequency distribution diagram showing the generation frequency of quantized data obtained through intra frame coding;

Fig. 9 is a frequency distribution diagram showing the generation frequency of quantized data obtained by inter frame coding;

Figs. 10A and 10D are schematic diagrams showing a DCT coefficient scanning procedure;

Figs. 11A to 11C are schematic diagrams for explaining quantized data having two-dimensional data of runs and levels;

Fig. 12 is a chart showing a VLC table for inter frame coding;

Fig. 13 is a chart showing assignment of bits in accordance with a VLC table for inter frame coding;

Fig. 14 is a chart showing a VLC table for intra frame coding;

Fig. 15 is a chart showing assignment of bits in accordance with a VLC table for intra frame coding;

Fig. 16 is a block diagram showing a decoding system using variable length decoding according to an embodiment of this invention;

Fig. 17 is a block diagram showing a hybrid decoder;

Fig. 18 is a block diagram showing a coding system using variable length coding according to an embodiment of this invention;

Fig. 19 is a block diagram showing a table change signal generator;

Fig. 20 is a flow chart for explaining a variable length coding procedure; and

Fig. 21 is a block diagram showing a decoding apparatus using variable length coding according to an embodiment of this invention.

Preferred embodiments of this invention will be described with reference to the accompanying drawings:

(1) First embodiment

(1-1) Constitution of encoder

In Fig. 5, 20 r presents an encoder constituting a motion picture coding apparatus as a whol , which is characterized by using two types of variable length coding tables corresponding to the coding syst m to improve a coding efficiency. A frame m mory 21 fetches input picture signals S0 in order and supplies picture data S1 to be processed at present in macroblocks to a hybrid coder 22.

The hybrid coder 22 movement compensation predicted codes the picture data S1 and thereafter hybrid codes the picture data S1 by discrete cosine transform (DCT).

The hybrid coder 22 supplies picture information to a variable length coding (VLC) section 23 as a quantized signal S2 and control information to it as a picture coding control signal S3 among processed results obtained by hybrid coding.

The VLC section 23 inputs the quantized signal S2 to a VLC circuit 23A and the picture coding control signal S3 to a VLC circuit 23A and a table changer 23B. In this connection, the quantized signal S2 has a DCT coefficient which is a movement compensation predicted error signal in a macroblock layer and run length information and the picture coding control signal S3 has control information including movement vector, macroblock type (presence or absence of movement compensation mode and DCT coefficient), and DCT mode.

The VLC circuit 23A variable length codes the DCT coefficient inputted as the quantized signal S2 based on two conversion tables (that is, the VLC table 23C for intra frame coding and the VLC table 23D for inter frame coding).

The movement compensation mode signal inputted as the picture coding control signal S3 is used to exchange the two conversion tables in the VLC circuit 23A. Exchanging the two conversion tables is described below by referring to Fig. 6.

First, the VLC circuit 23A starts with a processing routine RT0. When the VLC circuit 23A inputs the DCT coefficient and run length information from the hybrid coder 22 in the step SP1, it judges if the picture data to be processed is an intra frame coding mode or not in the next step SP2.

If so, the VLC circuit 23A proceeds to the step SP3 and references the VLC table 23C for intra frame coding to obtain corresponding variable length coded data. If not, the VLC circuit 23B proceeds to the step SP4 and references the VLC table 23D for inter frame coding to obtain corresponding variable length cod d data.

Then, the VLC circuit 23A transfers the variable length coded data obtained by reference to each table to a buffer memory 24 for transmission (step SP5) and then terminates all processing (step SP6).

Thereby, the VLC circuit 23 variable length codes quantized data together with a quantizing step size and macroblock (movement compensation mode) and supplies it to the transmission buffer memory 24 as transmission data.

The buffer memory 24 stores the data thus variabl l ngth coded and thereafter outputs the data as a bit stream at a certain transmission rate.

In this case, the buffer memory 24 returns quantization control signals in macroblocks to a quantization circuit based on the data quantity remaining in the memory so as to control the quantizing step size. The buffer memory 24 thereby adjusts the data quantity generated as a bit stream to keep the data in the memory at a proper quantity (a data quantity causing no overflow or underflow).

That is, when the quantity of remaining data increases up to the allowable upper limit, the buffer memory 24 decreases the quantity of quantized data by increasing the quantizing step size of the quantization circuit with the quantization control signal. However, when the quantity of remaining data decreases down to the allowable lower limit, the buffer memory 24 increases the quantity of quantized data by decreasing the quantizing step size of the quantization circuit with the quantization control signal.

(1-2) Constitution of hybrid coder

Signal processing of the hybrid coder 22 is described below by referring to Fig. 7.

The hybrid coder 22 supplies a block format picture to a motion vector detection circuit 22A through the frame memory 21 to detect a motion vector.

The motion vector detection circuit 22A, as already described in Fig. 2, generates an interpolation picture by using a noninterpolation frame (that is, intra frame predicted frame) as a predicted picture and using the detected motion vector.

In this case, the motion vector detection circuit 22A processes the picture data for each frame as an intra picture, predicted picture, or bidirectional picture based on previously set predetermined sequences.

The frame memory 21 stores the picture data for each frame in a front original picture memory section 21A, reference original picture memory section 21B, or rear original picture memory section 21C in accordance to these predetermined sequences.

The motion vector detection circuit 22A reads a reference picture DATA and predicted picture DATA (that is, front original picture and rear original picture) from the original picture memory sections 21A to 21C to detect the motion vector for each block. At this time, the motion vector detection circuit 22A uses the minimum value among the absolute value sums of inter frame differences.

The motion vector detection circuit 22A transmits the absolute value sums of inter frame differences obtained in blocks to an intra frame/forward/bidirectional predicted judgment circuit 22B.

The intra frame/forward/bidir ctional predicted judgm nt circuit 22B d termines th frame type of a reference block along with the absolute value sums and exchanges th processes of an operation section 22C in macroblocks in along with the d termined frame type.

In the case of an intra frame coded frame, the operation section 22C outputs a picture inputted from the motion vector detection circuit 22A through a switching circuit 22C3.

For a forward pr dicted coded frame or bidirectional predicted coded frame, a subtracter 22C1 or 22C2 generates intra frame coded data from a predicted picture and outputs the differential data through the switching circuit 22C3.

After a discrete cosine transform (DCT) circuit 22D inputs intra frame coded or inter frame coded picture data from a computing unit 22C, it discrete cosine transforms the input picture data or differential data in blocks by using two dimensional correlation of video signals.

A quantizer 22E quantizes the DCT coefficient obtained by transforming a macroblock and a quantizing step size determined for each slice and outputs the quantized data obtained through the quantization at an output terminal to a variable length coding section 23.

In this connection, the quantizing step size of the quantizer 22E is determined to a value so as not to exceed the capacity of a transmission by returning the remaining capacity of the transmission buffer. The quantizing step size is also outputted to the variable length coding circuit 23.

The hybrid coder 22 inputs the quantized data and quantizing step size to be outputted to the variable length coding section 23 to an inverse quantizer 22F to start local decoding.

The inverse quantizer 22E decodes the data to be transformed in the quantizer 22E by inversely quantizing the quantized data sent from the quantiz r 22E into a representative value and transforming it into inversely quantized data and supplies the inversely quantized data to an inverse discrete cosine transform (IDCT) circuit 22G.

The IDCT circuit 22G transforms the inversely quantized data decoded by the inverse quantization circuit 22F into decoded picture data by a transform processing inverse to that of the DCT circuit 22D and inputs it to a computing unit 22H.

Data same as the predicted picture data supplied to the computing unit 22C is supplied to the computing unit 22H so as to add the predicted picture data outputted by a motion compensation circuit 22J to the differential data outputted by the IDCT circuit 22G.

Thereby, picture data for the original (restored) predicted picture and picture data for the original (restored) intra picture are obtained and stored in a rear original picture memory section 22I1 and a front original picture memory section 22I2 of a frame memory 22I r spectiv ly.

After th picture data is stored in the rear original picture memory section 22I1 and front original picture memory section 22I2 respectiv ly, the motion vector detection circuit 22A starts the next picture process-

ing.

The motion compensation circuit 22J generates predicted picture data by using the picture data stored in the original picture memory sections 22I1 and 22I2 in accordance with the fram_ type determined by the intra frame/forward/bidirectional predicted judgment circuit 22B.

That is, for the backward predicted frame, the motion compensation circuit 22J sends a read address deviated by a value corresponding to a motion vector from a position corresponding to the position of a block to be inputted to the operating unit 22C to the rear original picture memory section 22I1 and generates predicted picture data.

For the bidirectional predicted frame, however, the motion compensation circuit 22J sends a read address deviated by a value corresponding to a motion vector from a position corresponding to the position of a block to be inputted to the operating unit 22C to the rear original picture memory sections 22I1 and 22I2 and generates predicted picture data.

(1-3) Variable length coding table

The following is the description of two types of coding tables prepared to efficiently code the quantized data S2 to be inputted from the hybrid coder 22 to the VLC apparatus 23.

The VLC apparatus 23 earns the coding efficiency in varying the sign length of quantized data coded in accordance with a combination of 0-run length (run length) with a quantized data level depending on a generation frequency. For this example, the VLC table 23C for intra frame coding and VLC table 23D for inter frame coding are prepared.

This is because intra frame coded quantized data and inter frame coded quantized data are different from each other in the frequency distributions of a run length and level.

That is, the intra frame coded quantized data is concentrated on a low frequency component because intra frame coding discrete cosine transforms a pattern itself. Therefore, a run length tends to comparatively decreases and a level tends to comparatively rises as shown in Fig. 8.

For the inter frame coded quantized data is scattered up to a high frequency component because a difference with the pattern of other frame is discrete cosine transformed as shown in Fig. 9. Therefore, a run length tends to comparatively increases and a level tends to comparatively lower.

The VLC table 23C for intra frame coding and VLC table 23D for inter frame coding are the coding tables assign d with signs so that the sign length of quantized data can be efficiently decreased by reflecting the above composition.

The quantized data S2 to be variable length coded here is obtained by quantizing a DCT coefficient transformed by the scan procedure shown in Figs. 10A to 10D no matter when the data is coded by any coding method.

In general, the quantized data S2 is formed in accordance with a combination of 0-run length with a quantized data level (that is, run and level) as shown in Figs. 11A to 11C. However, when the entire quantized data remaining without being scanned is 0, it is notified to the quantized data S2 by sending end of block (EOB) code that there is no level other than 0 up to finally coded quantized data.

Figs. 12 and 13 show the VLC table 23D for inter frame coding prepared for the quantized data S2 expressed by the format and Figs. 14 and 15 show the VLC table 23C for intra frame coding. In Figs. 12 and 14, the central column shows run length values and the right column shows level values. And, codes assigned to combinations of run lengths with levels are shown in the left column.

From Fig. 12, it is found that in case of the VLC table 23D for inter frame coding a sign with a small bit length is assigned to quantized data with a relatively high generation frequency and a large run length. This is also found from Fig. 13 showing the relationship between actually assigned sign length and combination of a run length with a level.

In other words, this is also found from the fact that a sign with the length of 9 bits is assigned to the quantized data with the run length of "0" and the level of "5" but only a sign with the length of 6 bits is assigned to the quantized data with the run length of "4" and the level of "1".

In this connection, the bit length shown in Fig. 13 is a value obtained by adding one bit to the code length of the VLC table 23D for inter frame coding shown in Fig. 12.

The VLC table 23D for inter frame coding assigns a code with the sign length of 20 bits to quantized data of a combination with a relatively low generation frequency instead of assigning a sign so as to fixed length code the quantized data. In this case, six bits of the above 20 bits are assigned to "ESCAPE code", six bits of them are assigned to "run length", and eight bits of them are assigned to "level".

From Fig. 14, it is found that in case of the VLC table 23C for intra frame coding a sign with a small bit length is assigned to quantized data with a relatively high generation frequency and a low level. This is also found from Fig. 15 showing the relationship between each combination and a sign length actually assigned to each combination.

In other words, this is also found from the fact that a sign with the length of 6 bits is assigned to quantized data with the run length of "0" and the level of "5" but only a sign with the l ngth of 7 bits is assigned to quantized data with the run length of "4" and the level of "1".

Also in the case of Fig. 15, the bit length assigned

for a combination of a run length with a level is a value obtained by adding one bit to the code length of the VLC table 23C for intra frame coding shown in Fig. 14.

The VLC table 23C for intra frame coding assigns a code with the sign length of 22 bits to quantized data of a combination with a relatively low generation frequency instead of assigning a sign so as to fixed length code the quantized data. In this case, eight bits of the above 22 bits are assigned to "ESCAPE code", six bits of them are assigned to "run length", and eight bits of them are assigned to "level".

(1-4) Constitution of decoder

The following is the description of the constitution of a decoder for restoring a motion picture from a bit stream coded by the encoder 20 and transmitted through a transmission path or media.

In Fig. 16, 30 represents a decoder constituting a motion picture decoding device as a whole. The decoder 30 temporarily stores a bit stream S10 inputted from media or the like in a receiving buffer memory 31 and successively inputs it to an inverse variable length coding (inverse VLC) section 32 at a predetermined timing.

The inverse VLC section 32 inverse VLC codes the information related to movement compensation of header information included in a bit stream S11 with an inverse VLC circuit 32A and thereafter supplies restored results to a table changer 32B as a motion compensation mode signal S13.

In this case, the table changer 32B selects the VLC table 32C for intra frame coding as an inverse transform table when the motion compensation mode of a macroblock to be processed is a intra frame coding mode but selects the VLC table 32D for inter frame coding as an inverse transform table when the motion compensation mode is an inter frame coding mode.

The inverse VLC circuit 32A refers to the inverse coding table thus selected by the table changer 32B to inverse VLC code a DCT coefficient and run length inputted as the bit stream S11.

The hybrid decoder 33 inputs from inverse VLC circuit 32A the DCT coefficient and run length information of the motion compensation predict error signal obtained for the macroblock layer and decoded data S12 of the motion vector and motion compensation mode, etc.

A hybrid decoder 33 restores picture data by decoding high efficiently coded data according to a procedure reverse to that of the hybrid coder 22.

(1-5) Constitution of hybrid decoder

The internal structure of the hybrid d coder 33 is d scribed below by referring to Fig. 17.

The hybrid decoder 33 sends a quantized step and picture data of the variable length coded data inputted from the inverse VLC section 32 to an inverse quantizer 33A and also sends a motion vector, predicted mode, predicted flag, and DCT flag to a motion compensation circuit 33D.

The inverse quantizer 33A inversely quantizes the picture data supplied from the inverse VLC apparatus 32 in accordance with the quantized step similarly supplied from the inverse VLC section 32 and supplies the data to an invert discrete cosine transform (IDCT) circuit 33B.

The IDCT circuit 33B inverse DCT transforms a DCT coefficient inputted from the inverse quantizer 33A to supply it to an operating unit 33C.

The operating unit 33C restores an original picture by adding the output of the IDCT circuit 33B to the data motion compensated by the motion compensation circuit 33D.

The picture data thus outputted from the computing unit 33C is outputted to an output terminal and also it is stored in a frame memory 33E.

The frame memory 33E is provided with a front predicted picture memory section 33E1 and a rear predicted picture memory section 33E2. The front predicted picture memory section 33E1 stores a predicted picture and an intra picture for generating a bidirectional picture and the rear predicted picture memory section 33E2 stores a predicted picture for generating a predict picture or bidirectional picture.

The motion compensation circuit 33D compensates the motion of picture data stored in the front pr dicted picture section 33E1 and rear predicted picture section 33E2 and sends the data to the computing unit 33C in accordance with a mode of the picture data to be decoded.

(1-6) Coding and decoding

The following is the description of coding by a motion picture coding section for successively coding motion pictures in accordance with a predetermined procedure with the above constitution.

The motion picture coding section stores a motion picture converted into digital data by a pre-processing circuit 2 or the like in the encoder 20 through a frame memory 21 to high efficiently code the data with the encoder 20.

The encoder 20 hybrid codes the picture data read from the frame memory 21 with the hybrid coder 22 and sends the quantized data which is motion compensated and DCT transformed and thereafter quantized to the VLC section 23.

The VLC section 23 variable length codes a coding table used for variable length coding by changing the VLC table 23C for intra frame coding and the VLC table 23D for inter frame coding correspondingly to two types of coding modes.

Thus, the VLC section 23 variable length codes a transmission picture by using the VLC table 23C for

intra frame coding for reflecting the genernerneration frequency of intra frame coded quantized data when the picture comprises intra frame coded picture data but variable length codes the picture by using the VLC table 23D for inter frame coding for reflecting the generation frequency of inter frame coded quantized data when the picture is composed of inter frame coded picture data.

The above configuration makes it possible to further decrease the bit length of transformed and thereafter outputted picture data even though it is the quantized data coded by any coding system, compared with the existing case in which variable length coding is performed by using a VLC table for inter frame coding.

Thereby, it is possible to decrease the transmission rate for transmitting the same motion picture compared with the existing one and decrease the quantized size by a value equivalent to the decrease of the transmission rate. Thus, for the coding system of this embodiment, it is possible to increase information content to be assigned to each pixel by a value equivalent to the decrease of the quantized size and further improve the picture quality compared with the existing one.

Moreover, because it is possible to use an existing coding table for the VLC table 23D for inter frame coding of this embodiment, the compatibility with existing models is also compensated.

In this connection, because the information about whether to perform intra frame or inter frame coding every macroblock is sent together with picture data even for an existing coding system, it is not necessary to newly add the information about which VLC table should be used to header information.

(2) Second Embodiment

(2-1) Constitution of Encoder

In Fig. 18 in which a portion corresponding to that in Fig. 5 is provided with the same symbol, symbol 40 represents an encoder constituting a motion picture coding system as a whole which has the same constitution as the encoder in Fig. 5 except a table change signal generator 41 for selecting a coding table requiring a small bit length regardless of a predicted coding system (frame type) by considering the information content generated by using each coding table in addition to the fact that two types of transform tables corresponding to a coding system are prepared as variable length coding tables.

The table change signal generator 41 has the constitution shown in Fig. 19.

Th table change signal generator 41 has two g nerated informati n counting sections t calculate the information content generated by using each transform tabl before starting variable length coding with the VLC apparatus 23.

The table change signal generator 41 inputs a DCT coefficient and run length information to two VLC circuits 41A and 418 from the hybrid coder 22 to variable length code quantized data with the VLC circuits 41A and 41B.

In this case, the VLC circuit 41A uses the VLC table 23C for intra frame coding as a coding table and the VLC circuit 41B uses the VLC table 23D for inter frame coding as a transform table.

The data variable length coded by the VLC circuit 41A and the data variable length coded by the VLC circuit 41B are sent to the number of bits counters 41C and 41D respectively where the number of bits representing the generated information content is counted. In this case, the number of bits counters 41C and 41D update the generated information content stored in memories 41C2 and 41D2 by sequentially adding the number of bits of newly coded variable length data to the number of bits stored in the memories 41C2 and 41D2 with adders 41C1 and 41D1.

A comparator 41E sends a data request signal SR to the memories 41C2 and 41D2 in order to compare the information content generated in macroblocks and compares the number of bits stored in the memory 41C2 with that stored in the memory 41D2 at the timing when a response signal SA representing that the number of bits of all macroblocks is requested from the memories 41C2 and 41D2 is inputted.

The comparator 41E outputs the comparison result to the VLC circuit 23A and table changer 23B of the VLC apparatus 23 as a table change signal. Thereby, the comparator 41E shows the VLC circuit 23A a coding table with which variable length coding should be performed and changes the connection of the table changer 23B.

A series of these processing by an encoder 40 is described by referring to Fig. 20.

The encoder 40 starts the processing of a processing routine RT1 when the processing by the hybrid coder 22 terminates and quantized data is obtained and then starts the processing in the steps SP10 and SP11. In the steps SP10 and SP11, the table change signal generator 41 counts the generated number of bits N1 when variable length coding quantized data by using the VLC table 23C for intra frame coding and the generated number of bits N2 when variable length coding quantized data by using the VLC table 23D for inter frame coding in order.

When counting of the generated number of bits N1 and the generated number of bits N2 for each macroblock terminat s, the table change signal generator 41 starts the n xt step SP12 to store the number of bits in a memory and det rmine a counted value.

The table change signal generator 41 decides a coding table for coding with which the generated number of bits is minimized in the next step SP13 (ac-

tually, comparison is performed by the comparator 41E).

When the table change signal generator 41 decides that the generated number of bits is minimized by the VLC table 23C for intra frame coding, it starts the step SP14 to control the table changer 23B so as to refer to the VLC table 23C for intra frame coding according to a change signal.

However, when the table change signal generator 41 decides that the generated number of bits is minimized by the VLC table 23D for inter frame coding, it starts the step SP15 to control the table changer 23B so as to refer to the VLC table 23D for inter frame coding according to a change signal.

When these changes terminate, the step SP16 is started and the VLC circuit 23A starts variable length coding the quantized data having a DCT coefficient and a run length fetched from the hybrid coder 22.

Moreover, the VLC circuit 23A adds a flag for designating the coding table used for variable length coding in the step SP17 to header information as control data.

In the step SP18, the VLC circuit 23A transfers variable length coded picture data to a buffer memory 24 for transmission together with the header information to temporarily store them and then writes the stored data in a transmission path or media from the buffer memory 24 to terminate the above coding.

(2-2) Constitution of Decoder

The constitution of a decoder for decoding picture data high efficiently coded by the encoder 40 is described below by referring to Fig. 21. In Fig. 21 in which a portion corresponding to that in Fig. 16 is provided with the same symbol, symbol 50 represents a decoder which has the same constitution as that in Fig. 16 except that an inverse VLC circuit 51 is used instead of the inverse VLC circuit 32A of the inverse VLC section 32.

The inverse VLC circuit 51 inversely VLC codes header information to extract a flag showing the coding table selected in variable length coding among the transform results and use it to change the table changer 32B.

As the result of the above change, the inverse VLC circuit 51 refers to the transform table selected by the table changer 32B to inversely VLC transform a DCT coefficient and run length information inputted as bit streams.

(2-3) Coding and Decoding

The following is th d scription of coding p rform d by a motion picture coding system for successively coding motion pictures according to a pr determined procedure with the above constitution.

The motion picture coding system stores a motion picture converted into digital data by the pre-processing circuit 2 or the like in the encoder 40 through the frame memory 21 to high efficiently code the data with the encoder 40.

The encoder 40 hybrid codes the picture data read from the frame memory 21 with the hybrid coder 22 and sends the quantized data which is motion compensated and DCT transformed and thereafter quantized to the VLC apparatus 23.

In this case, the quantized data same as that sent to the VLC apparatus 23 is also inputted to the table change signal generator 41 to decide a coding tabl form minimizing the generated information content for variable length coding.

This is because intra frame coded quantized data of a macroblock includes data with a composition very close to inter frame coded quantized data of the macroblock and data with a composition not very close to it and therefore intra frame coded quantized data cannot be always transformed into smaller number of bits by using a VLC table for intra frame coding.

Therefore, intra frame coded quantized data of a macroblock with a composition very close to inter frame coded quantized data of the macroblock is variable length coded by using the VLC table 23D for inter frame coding and macroblocks other than the above macroblock are variable length coded by using the VLC table 23C for intra frame coding. Thereby, it is possible to further improve the coding efficiency for variable length coding.

In this case, because a coding table used for variable length coding does not depend on an intra frame coding system or inter frame coding system in general, it is necessary to code and transmit the information showing which VLC table is used for variable length coding together with variable length coded data.

Therefore, a VLC table formed by adding one bit to each macroblock is used.

The above constitution makes it possible to realize a variable length coding system with higher variable length coding efficiency than the existing one by variable length coding data with a composition close to quantized data generated through inter frame coding by using a VLC table for inter frame coding even when variable length coding quantized data generated through intra frame coding and selecting either of two coding tables for further decreasing generated information content for each block.

Therefore, it is possible to decrease the transmission rate for transmitting the same motion picture compared with the existing one and decrease the quantizing step size by a value equivalent to the decrease of the coding rate. Thus, the coding system of this embodiment makes it possible to increase the information content to be assigned to each pixel compared with an existing coding system which has only one VLC table and further improve the picture quality.

Moreover, though this variable length coding system requires additional information of one bit for each macroblock, generated information content can be decreased because it is possible to make the decrease rate of the number of bits larger than the increase rate of the number of bits for additional information by properly changing VLC tables.

(3) Other Embodiments

In the above embodiment, a video signal transmission system used for a video conference system and visual telephone system is described. However, this invention is not restricted to the system but it can be widely applied to a system using various types of recording and reproducing systems and a system using transmitting and receiving systems.

Moreover, in the above embodiment, a case is described in which the quantized data obtained from picture data is variable length coded. However, this invention is not restricted to the case but it can be widely applied to cases for variable length coding the quantized data obtained from other data such as voice data.

Furthermore, in the above embodiment, a case is described in which two variable length coding tables are prepared correspondingly to data which is intra framed coded and thereafter quantized and data which is inter frame coded and thereafter quantized. However, this invention is not restricted to the case but it can be applied to a case in which three or more variable length coding tables assigned with different sign lengths are prepared.

Furthermore, in the above embodiment, a case is described in which intra frame coded or inter frame coded picture data is discrete cosine transformed. However, this invention is not restricted to the case but it can be widely applied to cases for transforming the data with any other orthogonal coding system.

Furthermore, in the above embodiment, a case is described in which quantized data is variable length coded in macroblocks.

However, this invention is not restricted to the case but it can be widely applied to cases for using a block with any size as the processing unit.

Claims

1. A coding method for variable length coding quantized input data in predetermined blocks, comprising the step of:

   variable length coding the input data by using a variable l ngth coding tabl selected among a plurality of variable length coding tables (23C, 23D) prepared based on coding effici ncy.

2. A coding system for variable length coding quantized input data in predetermined blocks, comprising:

   a plurality of variable length coding tables (23C, 23D) assigned with different sign lengths;

   a coded information generating means (22) for designating change in variable length coding tables used for variable length coding the input data based on with coding efficiency; and

   coding means (23A, 23B) for variable length coding the input data by using a variable length coding table (23C, 23D) selected by coded information outputted from the coded information generating means.

3. A decoding method for decoding coded data inputted through a recording medium or transmission path in predetermined blocks, comprising the step of:

   selecting a variable length coding table identical to the variable length coding (23C, 23D) used when the coded data is generated among a plurality of variable length coding tables (32C, 32D) prepared and variable length decoding the encoded data by using the variable length coding table (32C, 32D).

4. A decoding system for variable length decoding coded data inputted through a recording medium or transmission path in predetermined blocks, comprising:

   a switching means (32B) for selecting a variable length coding table (32C, 32D) identical to variable length coding (23C, 23D) used when th coded data is generated in accordance with coded information extracted from the coded data among the variable length coding tables (32C, 32D); and

   a decoding means (32A) for variable length decoding the coded data by using a variable length coding table (32C, 32D) selected by the switching means (32B).

5. A coding system according to claim 2, wherein input data is data motion compensated and thereafter quantized, and the coded information is information generated based on a predictive coding system.

6. A decoding system according to claim 4, wherein;

   input data is data movement compensated and thereafter quantized, and the coded information is information gen rated bas d on a predictiv coding syst m.

7. A coding method according to claim 1, wherein:
   a variable length coding table is selected based on information content gen rated when variable length coding the input data by using each of the

prepared variable length coding tables without depending on a variable length coding table corresponding to a predictive coding system.

8. A coding system according to claim 2, wherein:
the coded information generating means designates a variable length coding table for variable length coding the input data based on the information content generated when variable length coding the input data by using each of the prepared variable length coding tables without depending on a variable length coding system corresponding to a predictive coding system.

9. A coding method according to claim 1, wherein:
each piece of information content generated when variable length coding the input data by using each of the variable length coding tables before variable length coding the input data is obtained to select a variable length coding table for variable length coding the input data based on the result of comparing the generated pieces of information content.

10. A coding system according to claim 2, wherein:
the coded information generating means obtains each piece of information content generated when performing variable length coding by using each of the variable length coding tables before the coding means variable length codes the input data and designates a variable length coding table for variable length coding the input data based on the result of comparing the generated pieces of information content.

11. A decoding method according to claim 3, wherein:
a variable length coding table selected based on the generated information content is selected among the prepared variable length coding tables without depending on a variable length coding table corresponding to a predictive coding system to variable length decode the coded data by using the variable length coding table.

12. A decoding system according to claim 4, wherein:
the switching means selects a variable length coding table for variable length coding the input data based on information content generated when variable length coding the input data by using each of the variable length coding prepared tables without depending on a variable length coding system corresponding to a predictive coding system.

13. A coding method according to claim 3, wherein:
a variable length coding tabl id ntical to the variable length coding table selected for coding is selected among the prepared variable length coding tables before variable length coding the input data to variable length decode the coded data by using the variable length coding table.

14. A decoding system according to claim 4, wherein;
the switching means selects a variable length coding table identical to the variable length coding table selected for coding among the prepared variable length coding tables before the decoding means variable length decodes the input data and variable length decodes the coded data by using the variable length coding table.

15. A coding system for variable length coding quantized data obtainable by the orthogonal transformation of picture data predictively coded for each macroblock, and thereafter quantizing the picture data, comprising:
a first variable length coding table suitable for the generation frequency of data quantized after intra frame coding;
a second variable length coding table suitable for the generation frequency of data quantized after inter frame coding;
a coded information generating means for designating change in the first and second variable length coding tables based on the fact that the quantized data is data intra frame coded or inter frame coded as predictive coding; and
a means for variable length coding the quantized data by using a first or second variable length coding table selected by coded information outputted from the coded information generating means.

16. A decoding system for variable length decoding coded data inputted through a recording medium or transmission path in macroblocks, comprising:
a first variable length coding table suitable for the generation frequency of data quantized after intra frame coding;
a second variable length coding table suitable for the generation frequency of data quantized after inter frame coding;
a changing means for extracting a coding method selected for predictive coding from among coded data to select the first variable length coding table when the coded data is data intra frame coded and thereafter variable length coded, and the second variable length coding table wh n the cod d data is data inter frame coded and th reafter variable length coded; and
a decoding means for variable l ngth decoding the coded data by using the first or second variabl length coding table selected by the switching means.

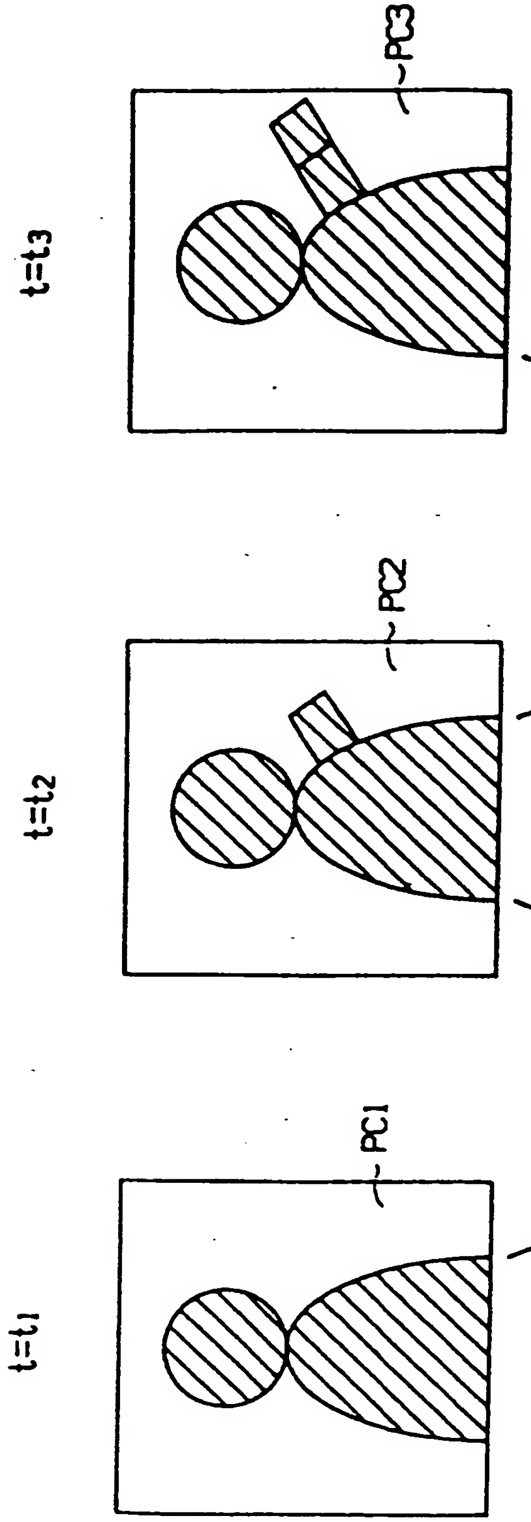

FIG. 1A

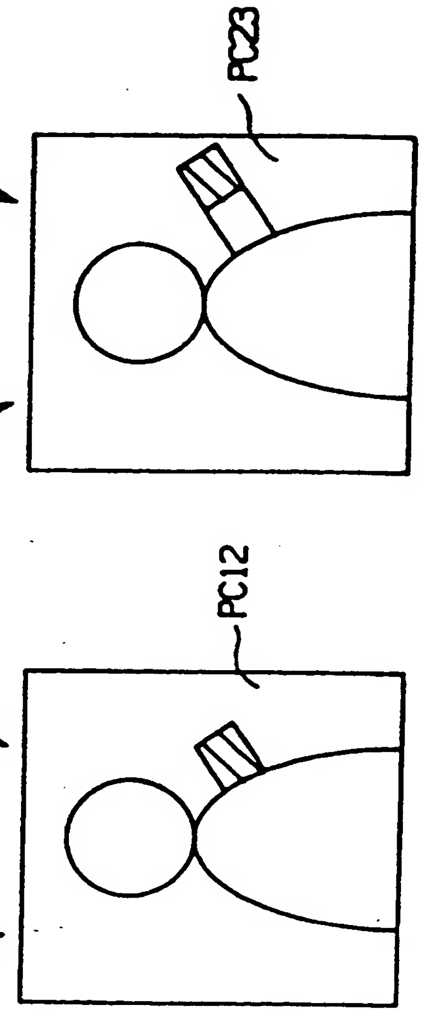

FIG. 1B

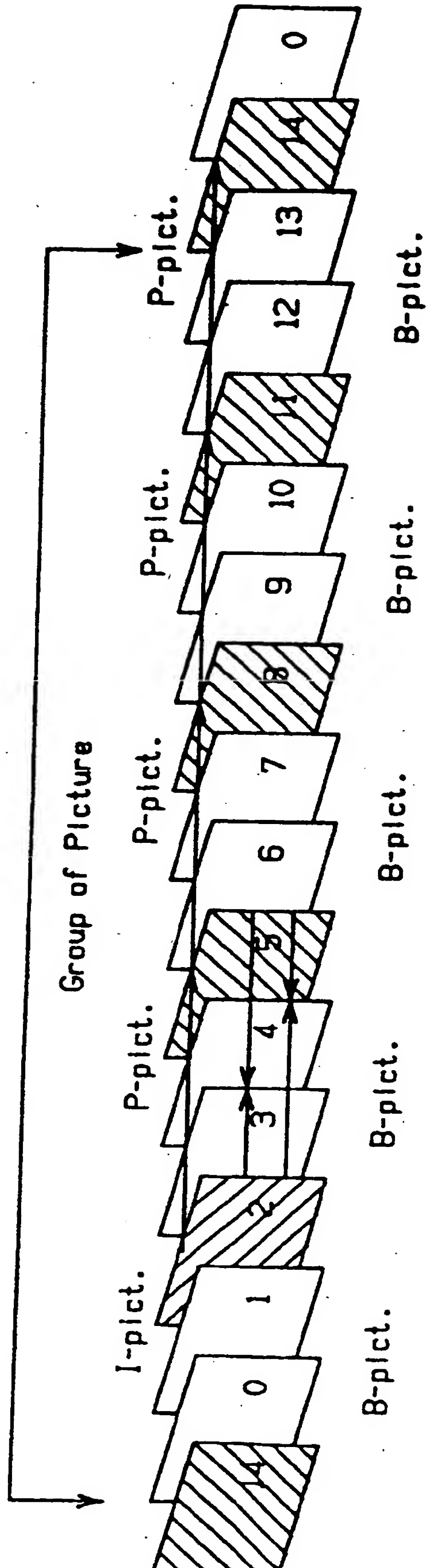
Group of Picture
I-pict.
P-pict.
P-pict.
P-pict.
P-pict.
B-pict.
B-pict.
B-pict.
B-pict.
B-pict.
B-pict.
14
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
0

FIG. 2

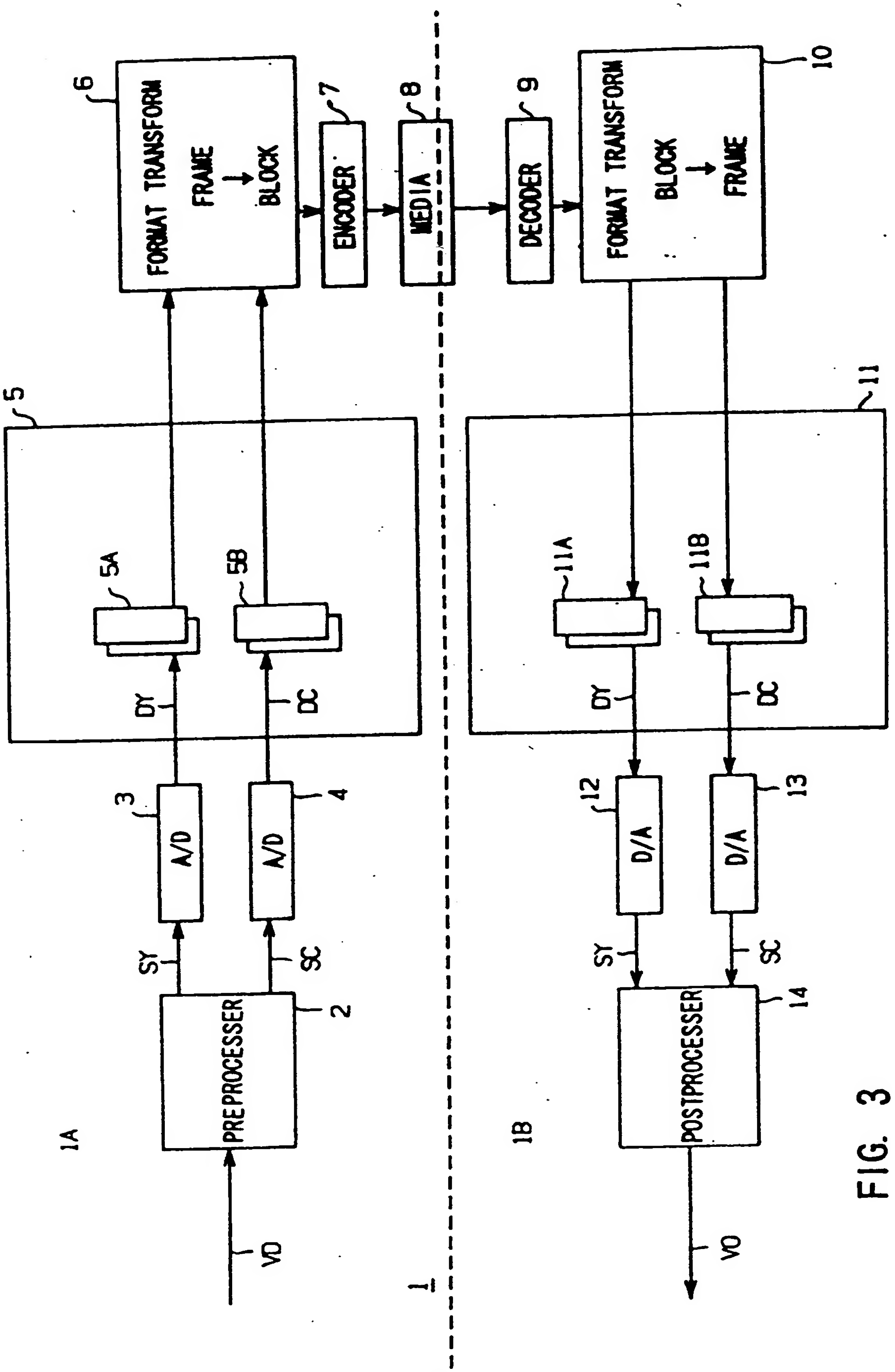
1A
1B
1
VD
PREPROCESSER
2
SY
SC
A/D
3
A/D
4
DY
DC
5
5A
5B
6
FORMAT TRANSFORM
FRAME → BLOCK
ENCODER
7
MEDIA
8
DECODER
9
FORMAT TRANSFORM
BLOCK → FRAME
10
11
11A
11B
DY
DC
D/A
12
D/A
13
SY
SC
POSTPROCESSER
14
VO

FIG. 3

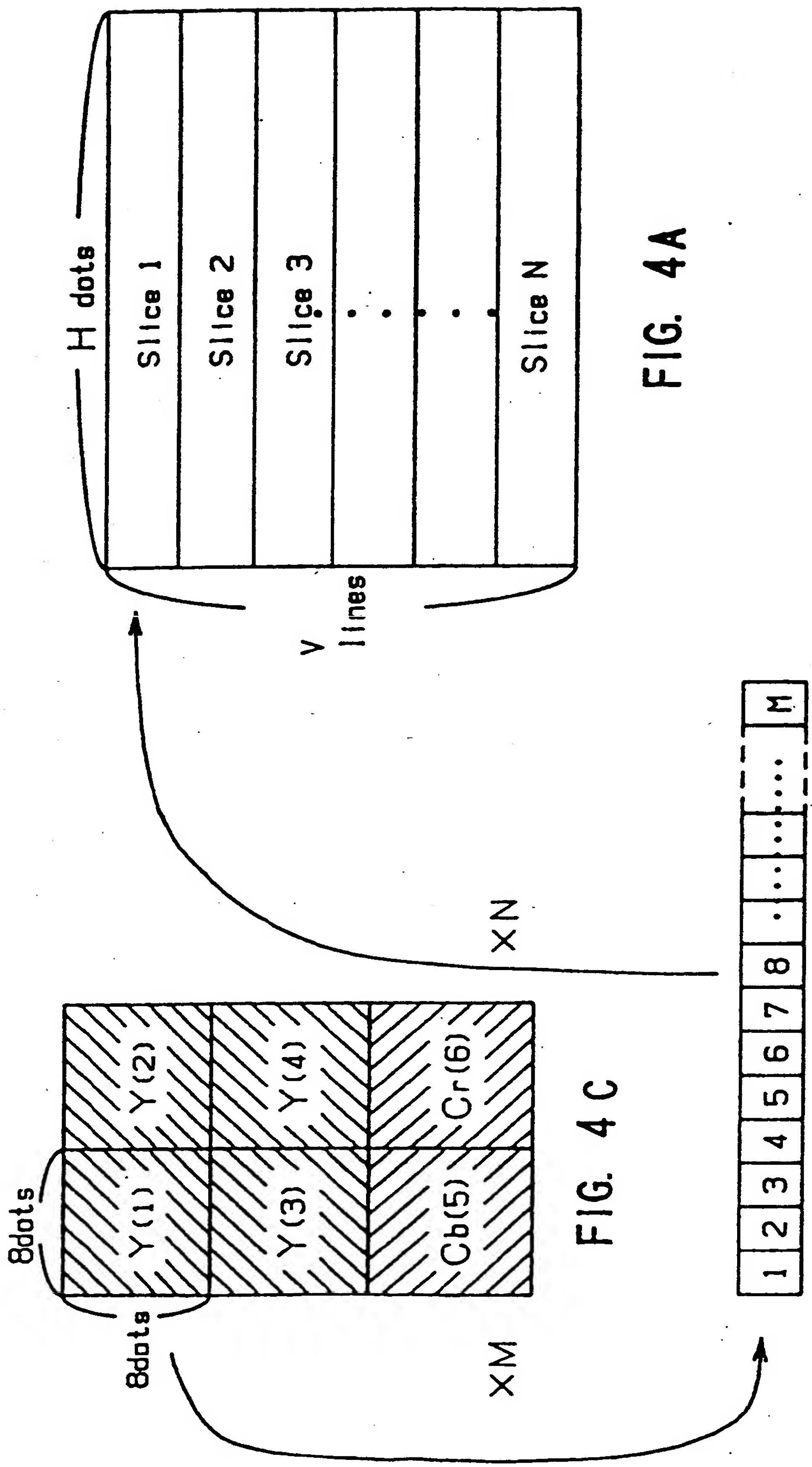

FIG. 4A

FIG. 4B

FIG. 4C

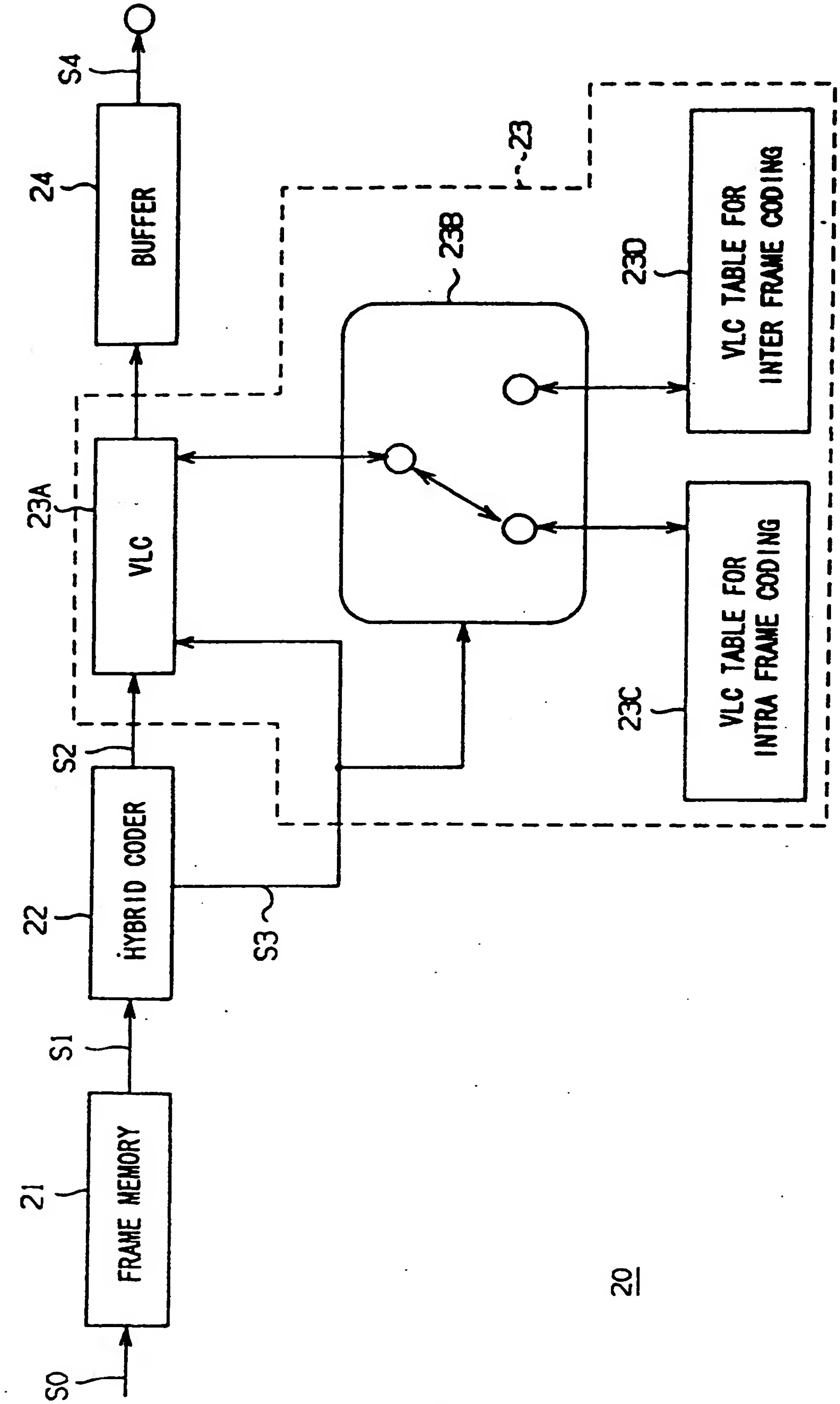
S0
FRAME MEMORY
21
S1
HYBRID CODER
22
S2
S3
VLC
23A
BUFFER
24
S4
23
23B
VLC TABLE FOR INTRA FRAME CODING
23C
VLC TABLE FOR INTER FRAME CODING
23D
20

FIG. 5

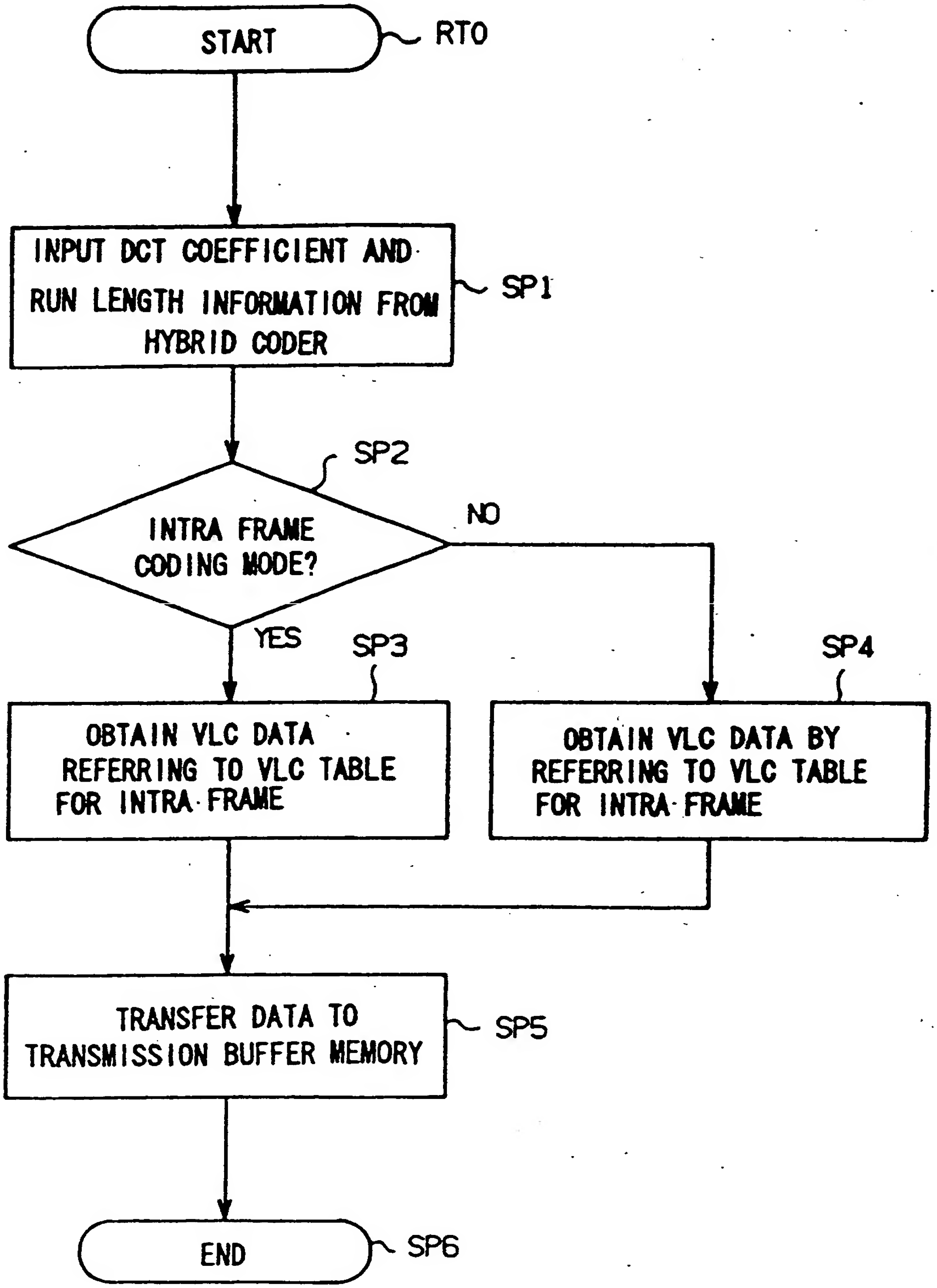
START
RT0
INPUT DCT COEFFICIENT AND RUN LENGTH INFORMATION FROM HYBRID CODER
SP1
SP2
INTRA FRAME CODING MODE?
NO
YES
SP3
SP4
OBTAIN VLC DATA REFERRING TO VLC TABLE FOR INTRA FRAME
OBTAIN VLC DATA BY REFERRING TO VLC TABLE FOR INTRA FRAME
TRANSFER DATA TO TRANSMISSION BUFFER MEMORY
SP5
END
SP6

FIG. 6

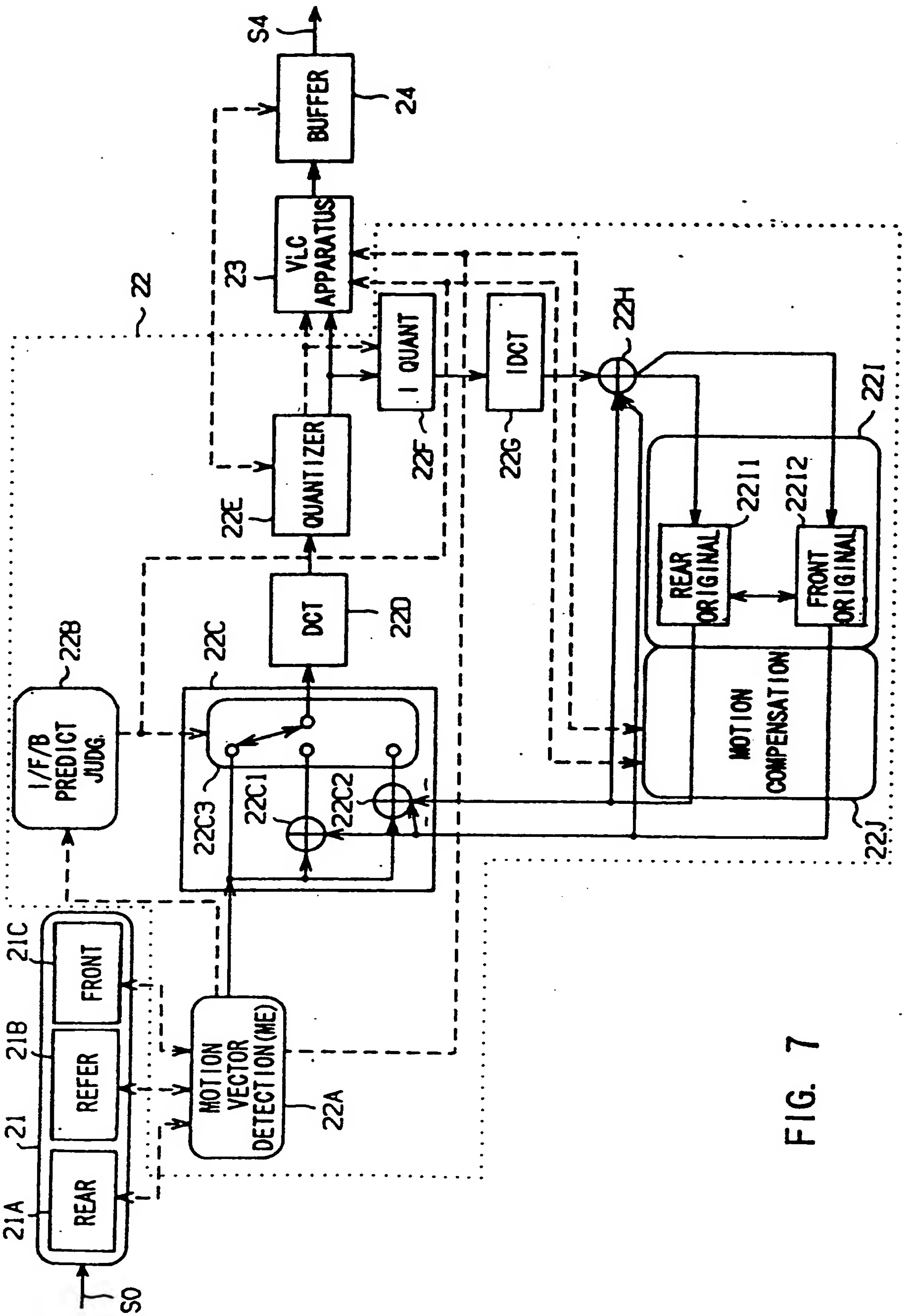
S0
21
21A
REAR
21B
REFER
21C
FRONT
MOTION VECTOR DETECTION (ME)
22A
I/F/B PREDICT JUDG.
22B
22C
22C1
22C2
22C3
DCT
22D
QUANTIZER
22E
I QUANT
22F
IDCT
22G
22H
VLC APPARATUS
23
BUFFER
24
S4
22
22I
REAR ORIGINAL
22I1
FRONT ORIGINAL
22I2
MOTION COMPENSATION
22J

FIG. 7

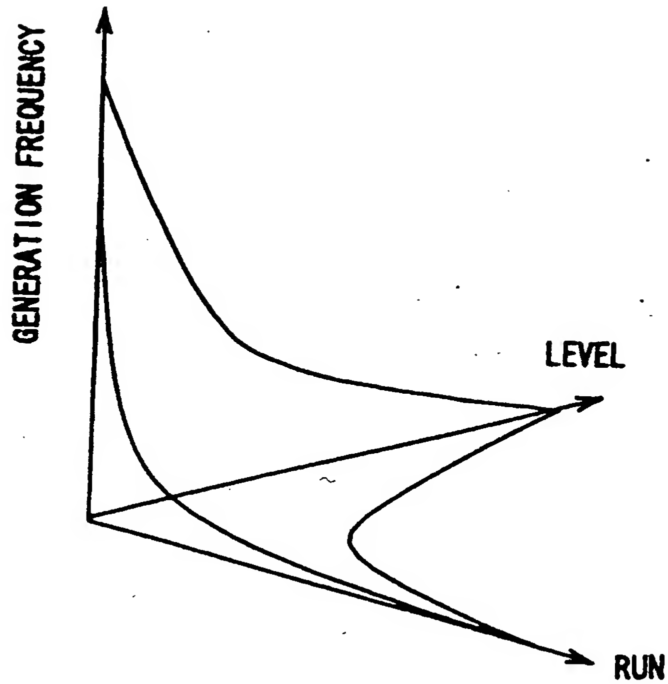
GENERATION FREQUENCY
LEVEL
RUN

FIG. 8

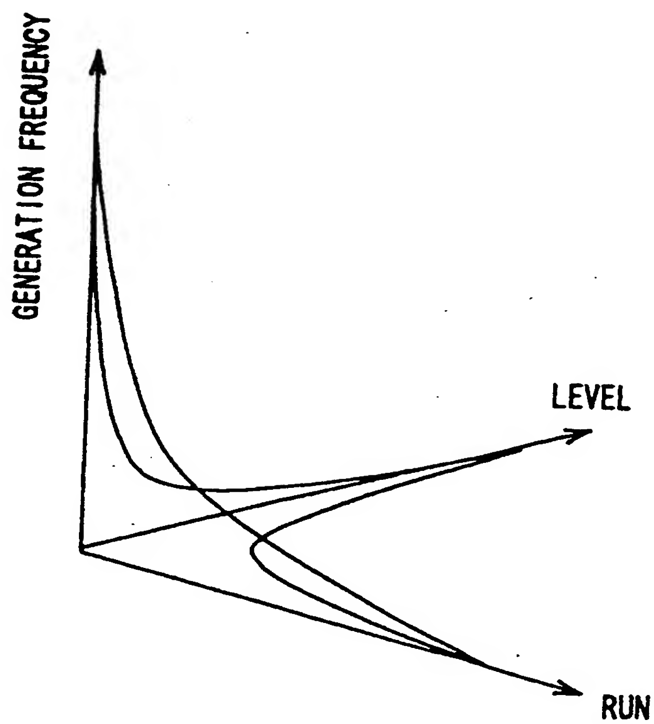
GENERATION FREQUENCY
LEVEL
RUN

FIG. 9

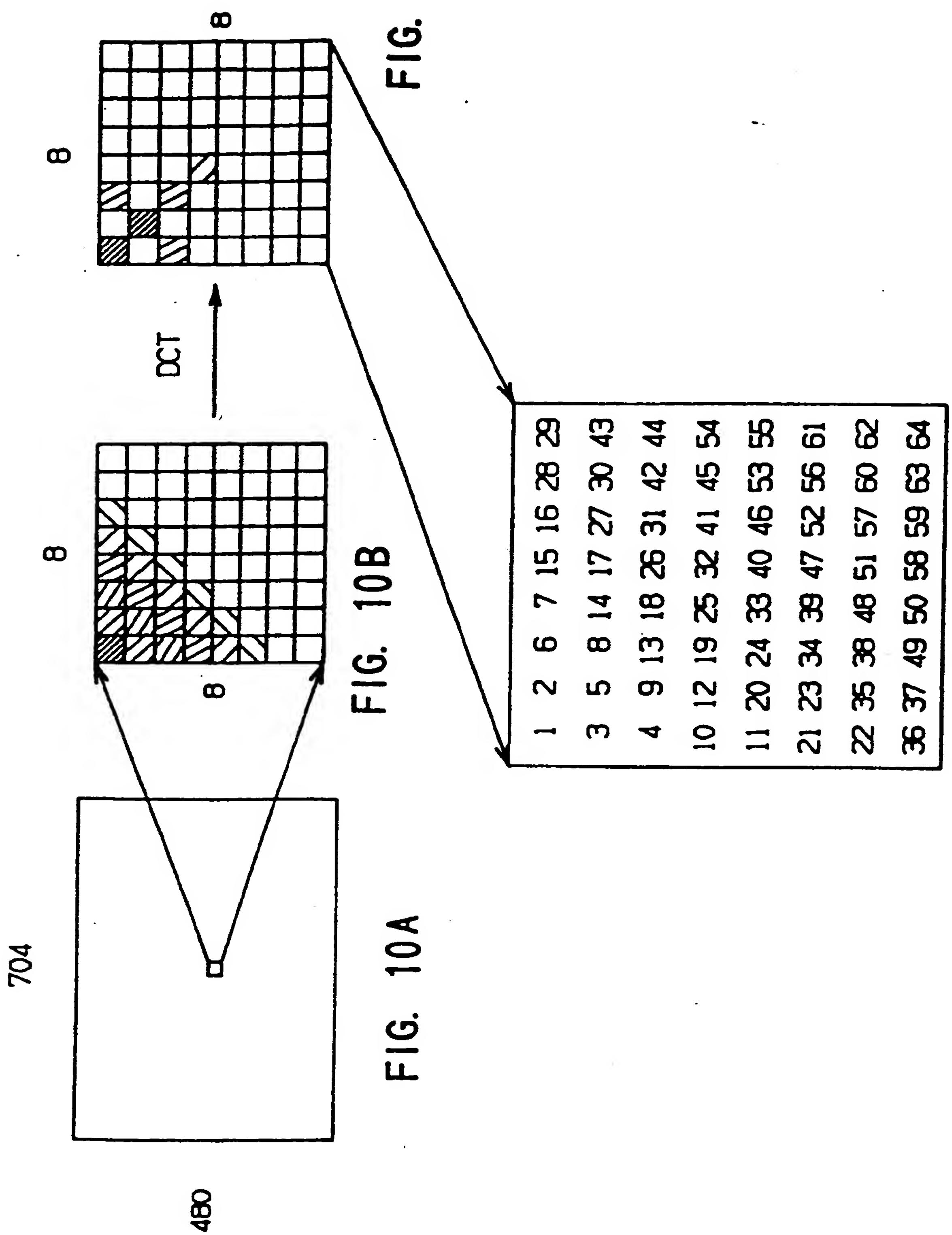

FIG. 10A

FIG. 10B

FIG. 10C

1	2	6	7	15	16	28	29
3	5	8	14	17	27	30	43
4	9	13	18	26	31	42	44
10	12	19	25	32	41	45	54
11	20	24	33	40	46	53	55
21	23	34	39	47	52	56	61
22	35	38	48	51	57	60	62
36	37	49	50	58	59	63	64

FIG. 10D

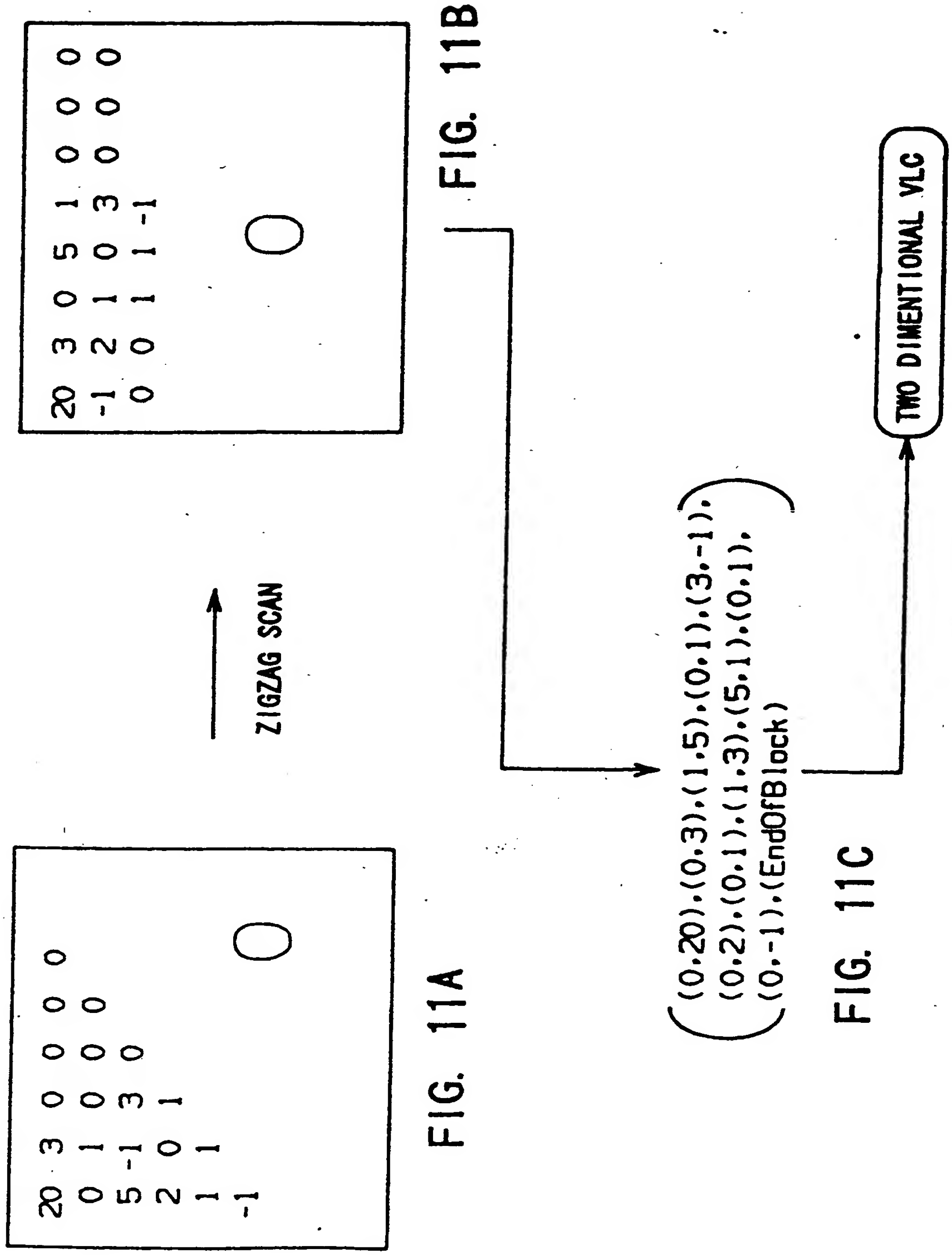

FIG. 11A

FIG. 11B

FIG. 11C

VLC Code	run	level
10	EOB	
11	0	1
011	1	1
0100	0	2
0101	2	1
00101	0	3
00111	3	1
00110	4	1
000110	1	2
000111	5	1
000101	6	1
000100	7	1
000110	0	4
0000100	2	2
0000111	8	1
0000101	9	1
000001	Escape	
00100110	0	5
00100001	0	6
00100101	1	3
00100100	3	2
00100111	10	1
00100011	11	1
00100010	12	1
00100000	13	1

FIG. 12

run \ level	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	3	5	6	8	9	9	11	13	13	13	13	14	14	14	14
1	4	7	9	11	13	14	14	16	16	16	16	16	16	16	17
2	5	8	11	13	14	20	20	20	20	20	20	20	20	20	20
3	6	9	13	14	20	20	20	20	20	20	20	20	20	20	20
4	6	11	13	20	20	20	20	20	20	20	20	20	20	20	20
5	7	11	14	20	20	20	20	20	20	20	20	20	20	20	20
6	7	13	17	20	20	20	20	20	20	20	20	20	20	20	20
7	7	13	20	20	20	20	20	20	20	20	20	20	20	20	20
8	8	13	20	20	20	20	20	20	20	20	20	20	20	20	20
9	8	14	20	20	20	20	20	20	20	20	20	20	20	20	20
10	9	14	20	20	20	20	20	20	20	20	20	20	20	20	20
11	9	17	20	20	20	20	20	20	20	20	20	20	20	20	20
12	9	17	20	20	20	20	20	20	20	20	20	20	20	20	20
13	9	17	20	20	20	20	20	20	20	20	20	20	20	20	20
14	11	17	20	20	20	20	20	20	20	20	20	20	20	20	20
15	11	17	20	20	20	20	20	20	20	20	20	20	20	20	20
16	11	17	20	20	20	20	20	20	20	20	20	20	20	20	20
17	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20
18	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20
19	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20
21	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20
22	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20
23	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20
24	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20
25	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20
26	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20

FIG. 13

VLC Code	run	level
11	0	1
101	0	2
110	1	1
0111	EOB	
0110	0	3
01011	0	4
01010	0	5
01001	1	2
01000	2	1
00111	3	1
001101	0	6
001100	0	7
001011	4	1
001010	5	1
0010011	0	8
0010010	0	9
0010001	1	3
0010000	2	2
0001111	6	1
0001110	7	1
0001101	8	1
0001100	9	1
0001011	10	1
00010101	Escape	
00010100	0	10
00010011	0	11
00010010	0	12
00010001	0	13
00010000	1	4
00001111	3	2
00001110	11	1
00001101	12	1
00001100	13	1

FIG. 14

run \ level	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
0	3	4	5	6	6	7	7	8	8	9	9	9	9	10	10	10	10	11	11	11	11	11	12	12	12	12	12	12	13	13	13	13	13
1	4	6	8	9	10	11	11	12	13	13	13	14	14	14	15	15	15	16	16	16	16	16	17	17	17	17	17	17	17	22	22	22	22
2	6	8	10	12	13	14	15	15	16	17	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
3	6	9	11	13	14	15	16	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
4	7	10	12	14	15	16	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
5	7	11	13	15	16	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
6	8	11	14	15	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
7	8	11	14	15	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
8	8	12	14	15	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
9	8	12	14	16	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
10	8	12	14	16	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
11	9	13	15	16	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
12	9	13	15	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
13	9	13	15	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
14	10	14	16	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
15	11	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
16	12	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
17	12	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
18	13	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
19	13	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
20	13	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
21	13	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
22	13	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
23	13	17	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22

FIG. 15

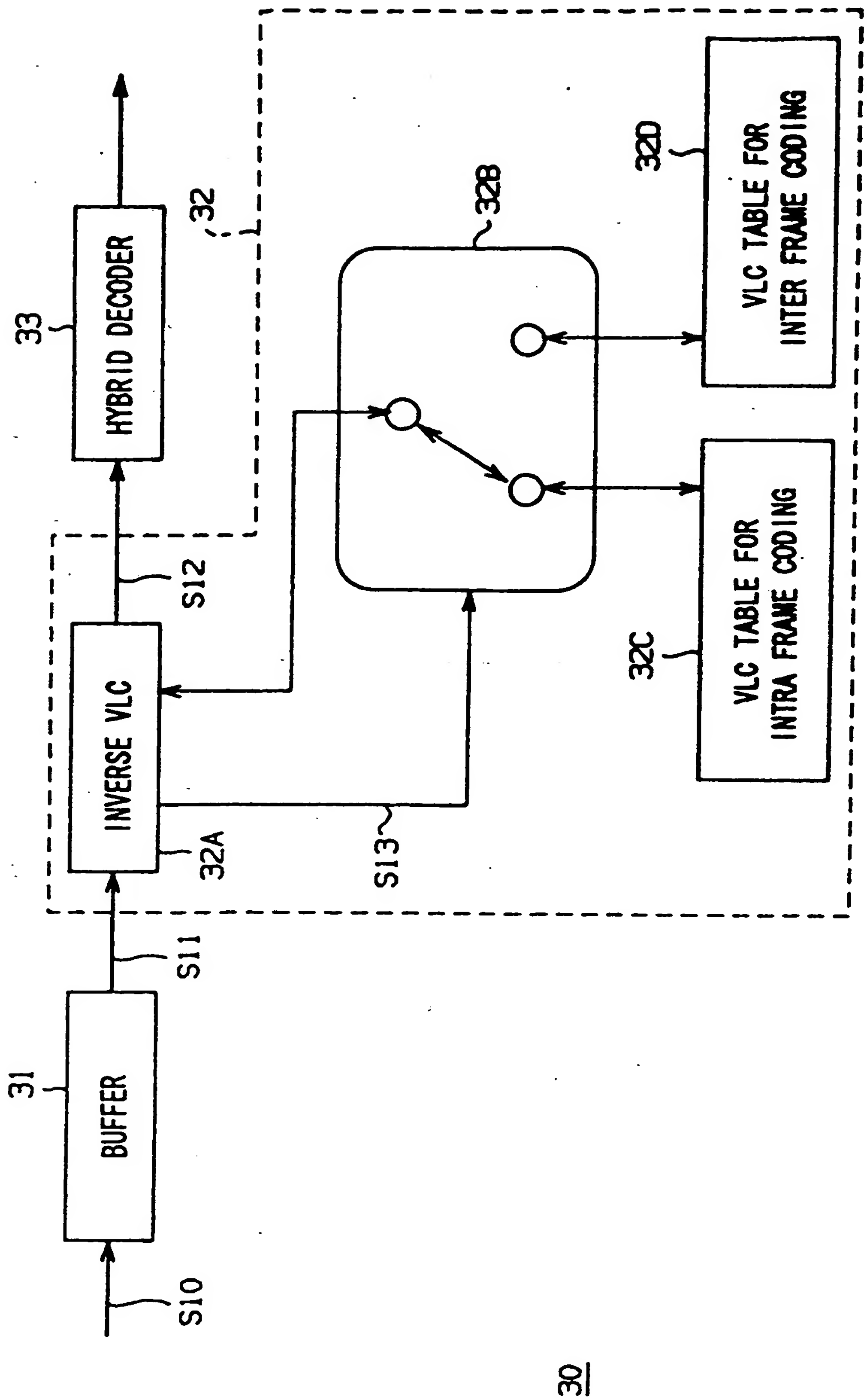
30
S10
31
BUFFER
S11
32A
INVERSE VLC
S12
S13
33
HYBRID DECODER
32
32B
32C
VLC TABLE FOR INTRA FRAME CODING
32D
VLC TABLE FOR INTER FRAME CODING

FIG. 16

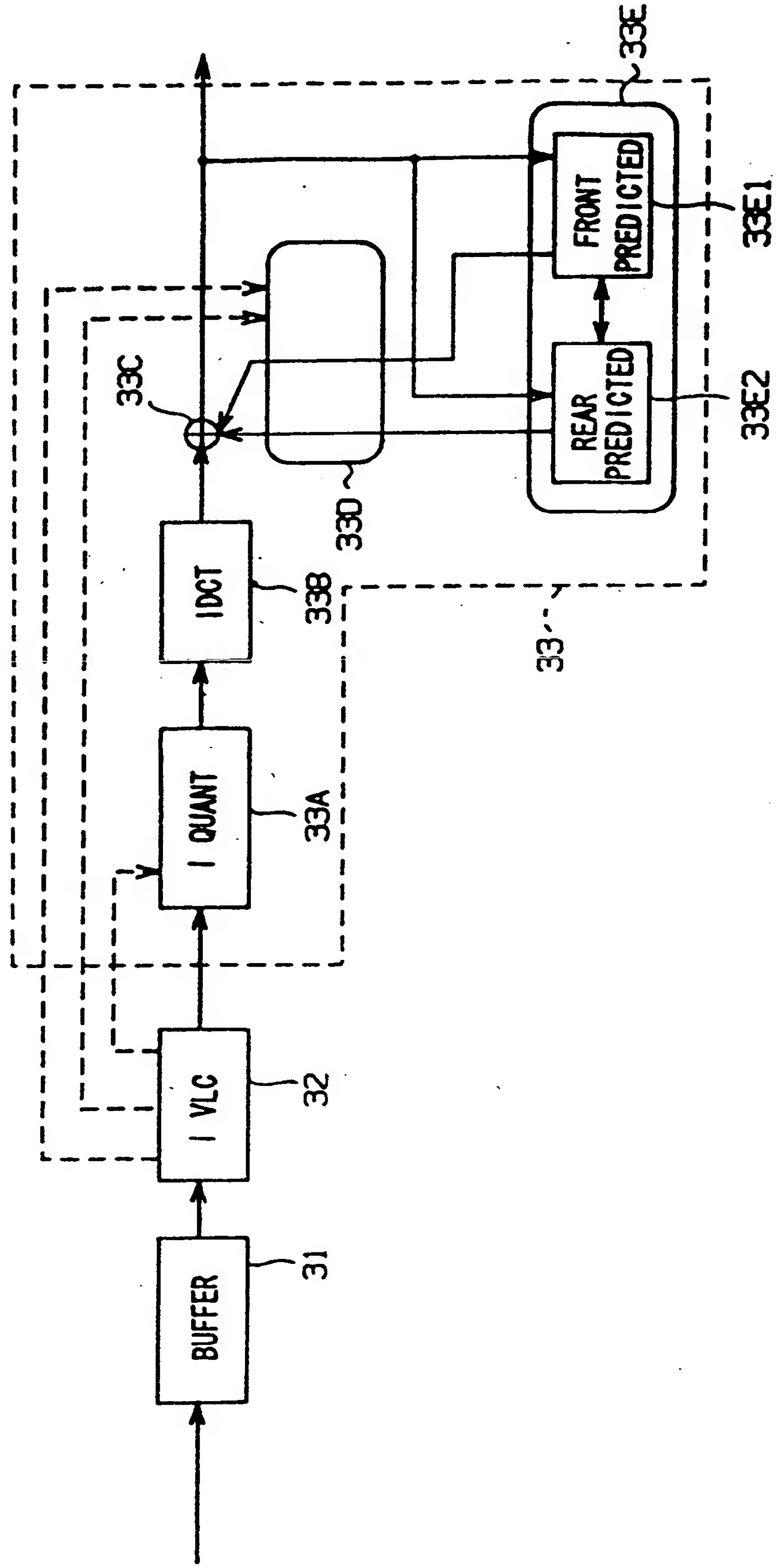
BUFFER
31
I VLC
32
I QUANT
33A
IDCT
33B
33C
33D
FRONT PREDICTED
33E1
REAR PREDICTED
33E2
33E
33

FIG. 17

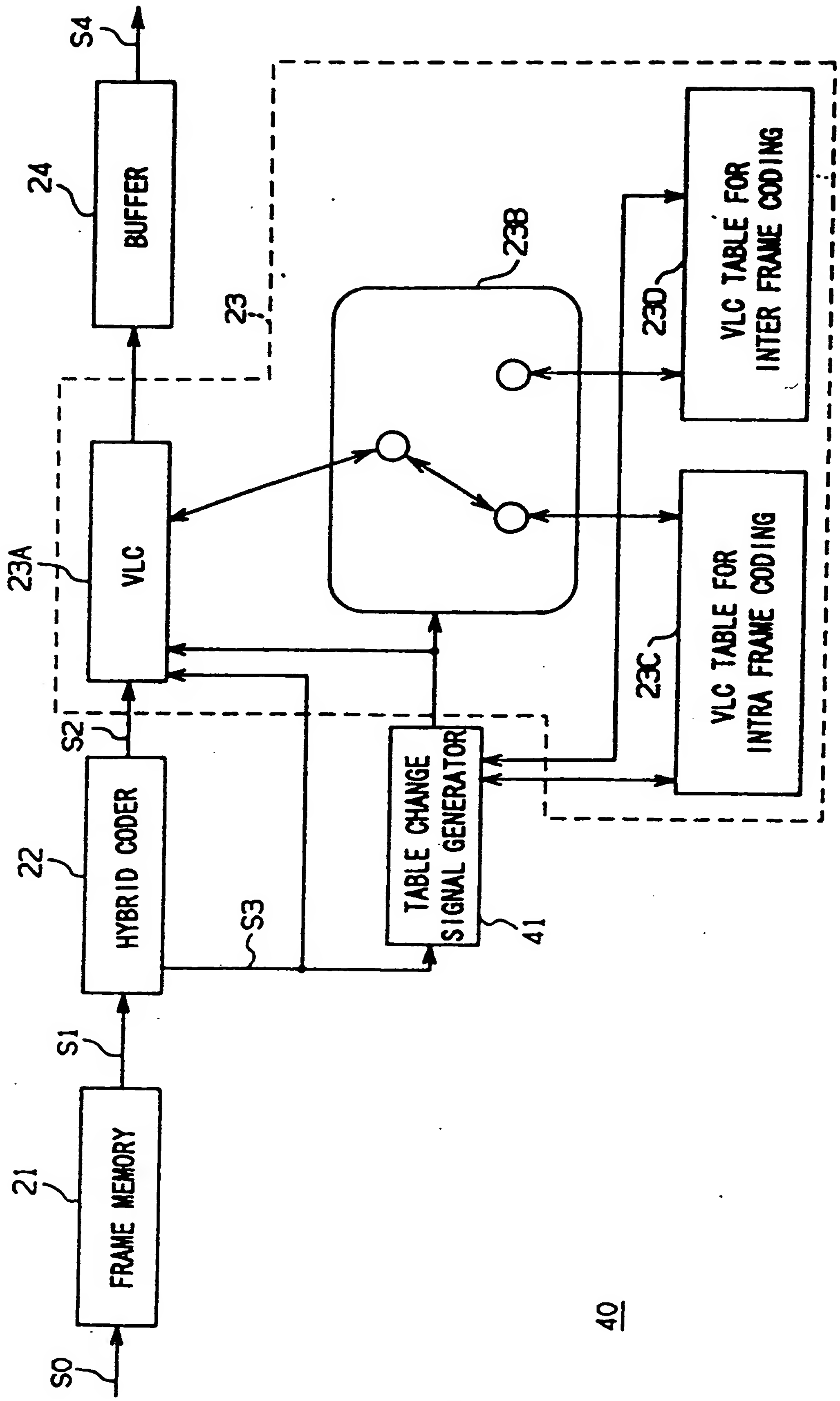
S0
FRAME MEMORY
21
S1
HYBRID CODER
22
S3
S2
VLC
23A
23
BUFFER
24
S4
TABLE CHANGE SIGNAL GENERATOR
41
23B
23D
VLC TABLE FOR INTER FRAME CODING
23C
VLC TABLE FOR INTRA FRAME CODING
40

FIG. 18

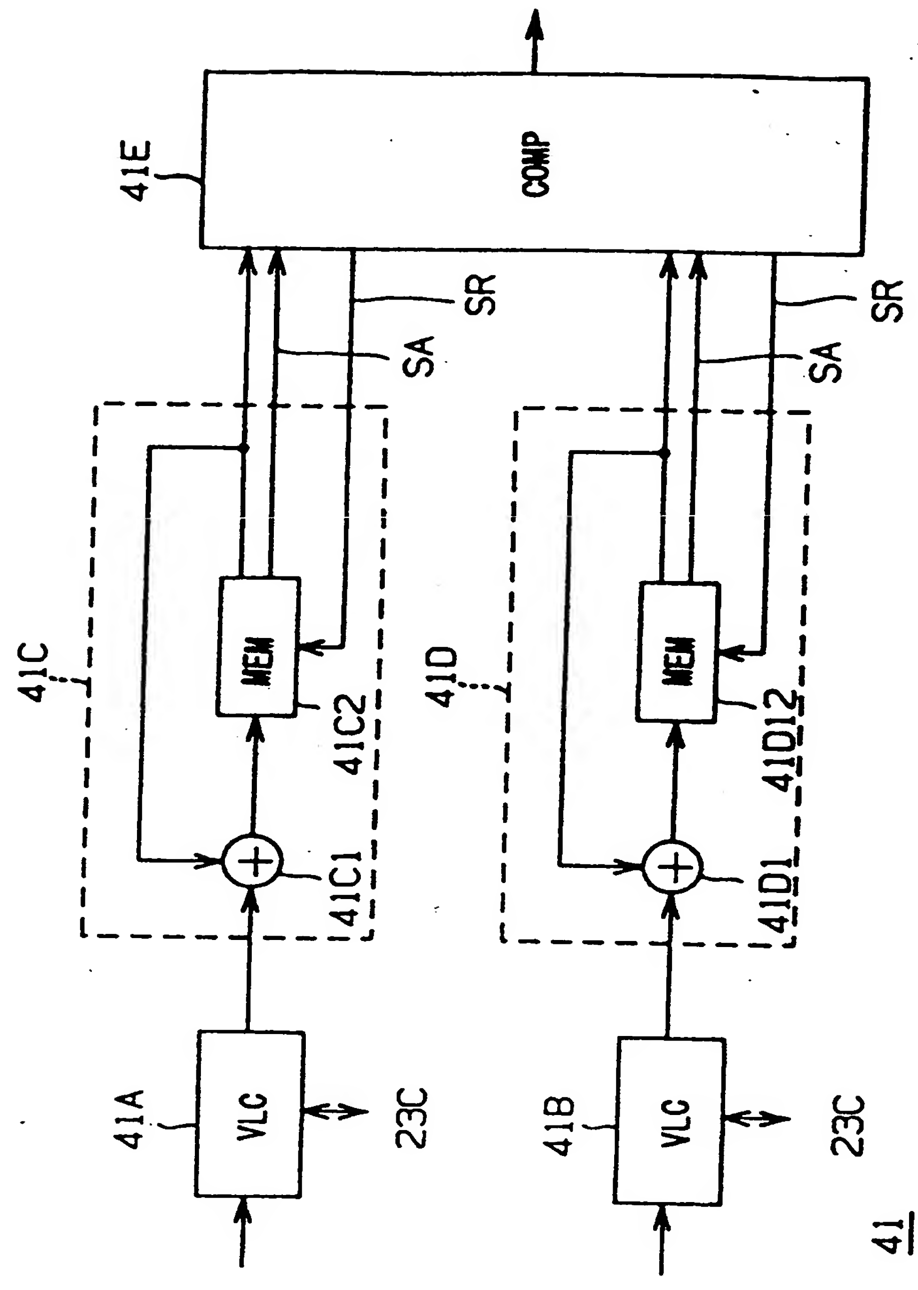
41E
COMP
SR
SA
SR
SA
41C
MEM
41C2
41C1
41D
MEM
41D12
41D1
41A
VLC
23C
41B
VLC
23C
41

FIG. 19

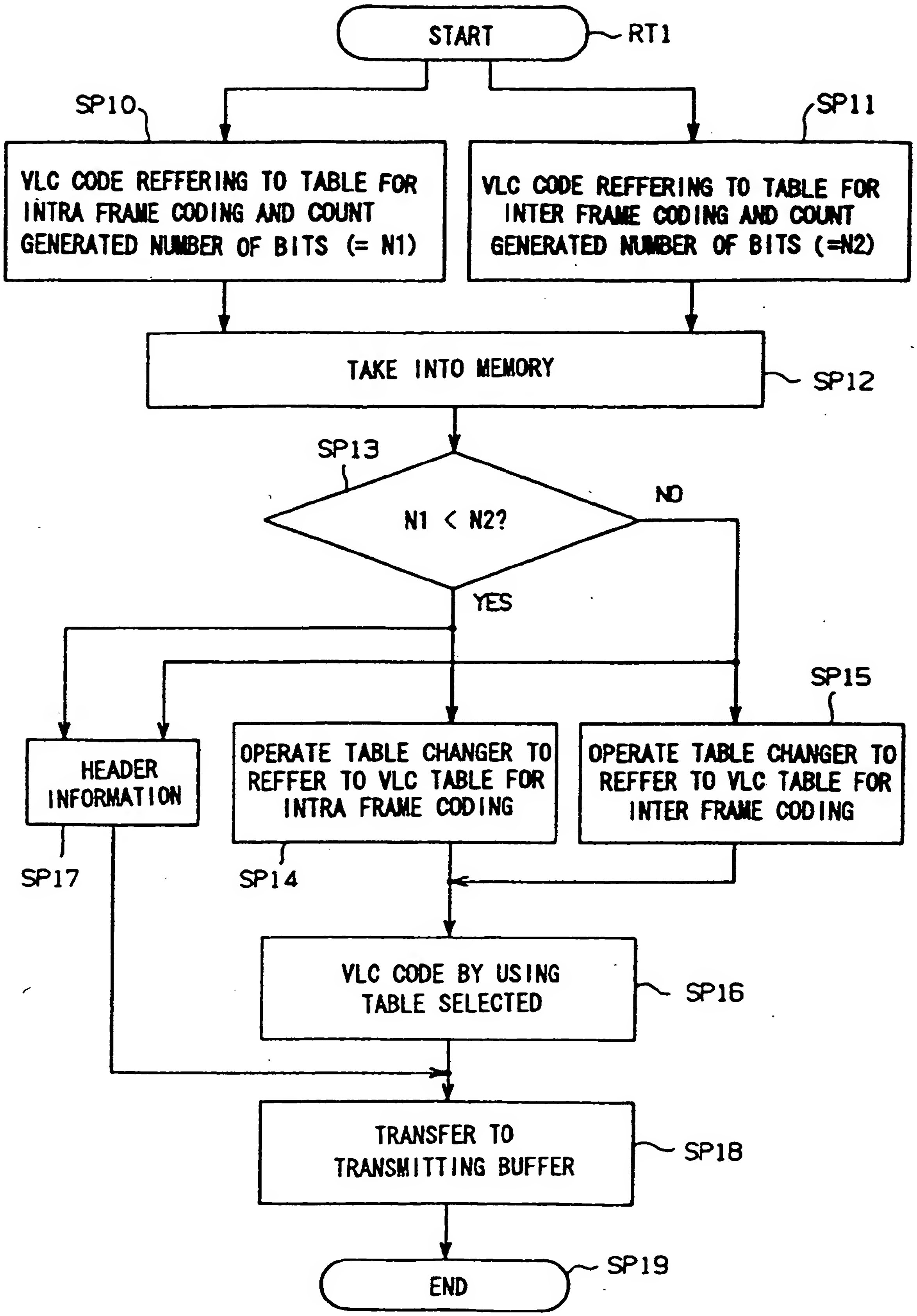
START
RT1
SP10
VLC CODE REFFERING TO TABLE FOR INTRA FRAME CODING AND COUNT GENERATED NUMBER OF BITS (= N1)
SP11
VLC CODE REFFERING TO TABLE FOR INTER FRAME CODING AND COUNT GENERATED NUMBER OF BITS (=N2)
TAKE INTO MEMORY
SP12
SP13
N1 < N2?
NO
YES
SP15
HEADER INFORMATION
OPERATE TABLE CHANGER TO REFFER TO VLC TABLE FOR INTRA FRAME CODING
OPERATE TABLE CHANGER TO REFFER TO VLC TABLE FOR INTER FRAME CODING
SP17
SP14
VLC CODE BY USING TABLE SELECTED
SP16
TRANSFER TO TRANSMITTING BUFFER
SP18
END
SP19

FIG. 20

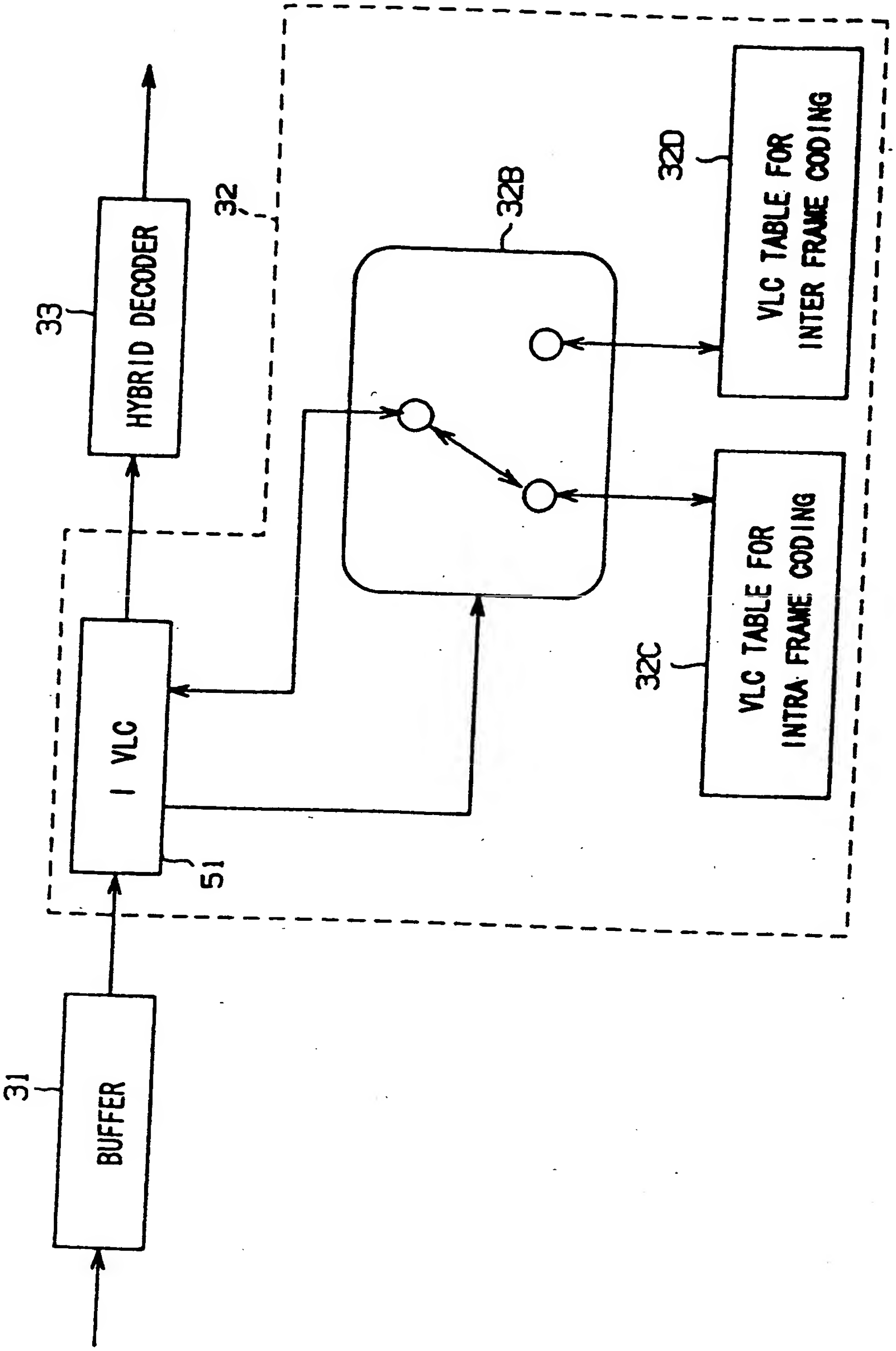
BUFFER
31
I VLC
51
HYBRID DECODER
33
32
32B
VLC TABLE FOR INTRA FRAME CODING
32C
VLC TABLE FOR INTER FRAME CODING
32D

FIG. 21

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Europ an Pat nt Office
Office uropé n d s br vets

(11) Publication number : **0 595 544 A3**

(12) **EUROPEAN PATENT APPLICATION**

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(22) Date of filing : **20.10.93**

(51) Int. Cl.^{5} : **H04N 7/13**, H04N 7/133

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04.05.94 Bulletin 94/18

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London EC4A 1DA (GB)

(54) **Coding and decoding methods and systems.**

(57) Input data is efficiently variable length coded by using a variable length coding table selected from among a plurality of variable length coding tables (23C, 23D) in accordance with a coding efficiency. It is thus possible further to improve variable length coding efficiency as compared with a case using only one variable length coding table. As a result, when generating information content equal to that generated by using only one variable length coding table, it is possible to process quantized data with a smaller quantization size and further to improve the quality of information transmitted as coded data.

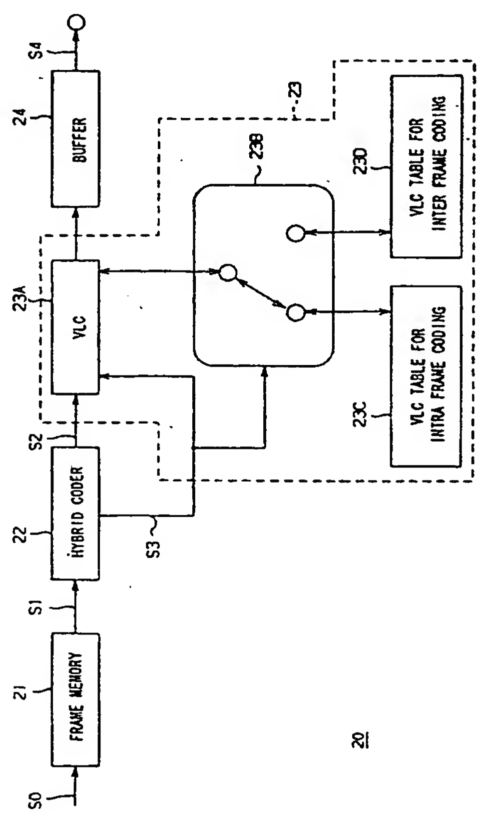

FIG. 5

EP 0 595 544 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 8349

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	INTERNATIONAL ORGANISATION FOR STANDARDIZATION - ISO/IEC JTC1/SC2/WG11, 13 November 1991 pages 1 - 74 SOURCE: MATSUSHITA 'MPEG Document 91/217' * page 3, line 1 - line 8 * * section 2.13 on page 13 *	1-16	H04N7/13 H04N7/133
X	EP-A-0 469 835 (CANON KABUSHIKI KAISHA) * claims 1,7; figures 5A,5B *	1,2,9,10	
X	PATENT ABSTRACTS OF JAPAN vol. 14, no. 553 (E-1010) 7 December 1990 & JP-A-02 237 368 (SHARP CORP.) 19 September 1990 * abstract *	1,9	
A	PATENT ABSTRACTS OF JAPAN vol. 16, no. 475 (E-1273) 2 October 1992 & JP-A-04 170 187 (OLYMPUS OPTICAL CO. LTD.) * abstract *	1-16	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, vol.38, no.1, February 1992, NEW YORK US pages XVIII - XXXIV G.WALLACE 'The JPEG still picture compression standard' * page XXIII, left column, line 26 - line 36; figures 1,2 *	1-16	H04N
P,X	EP-A-0 542 474 (AMERICAN TELEPHONE AND TELEGRAPH COMPANY) * page 7, line 30 - line 39 * * page 15, line 36 - page 16, line 10; figure 10 *	1-16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 October 1994	Giannotti, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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(22) Date of Filing 11.06.1993

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(51) INT CL^5
H04N 5/14, G06F 15/70

(52) UK CL (Edition M)
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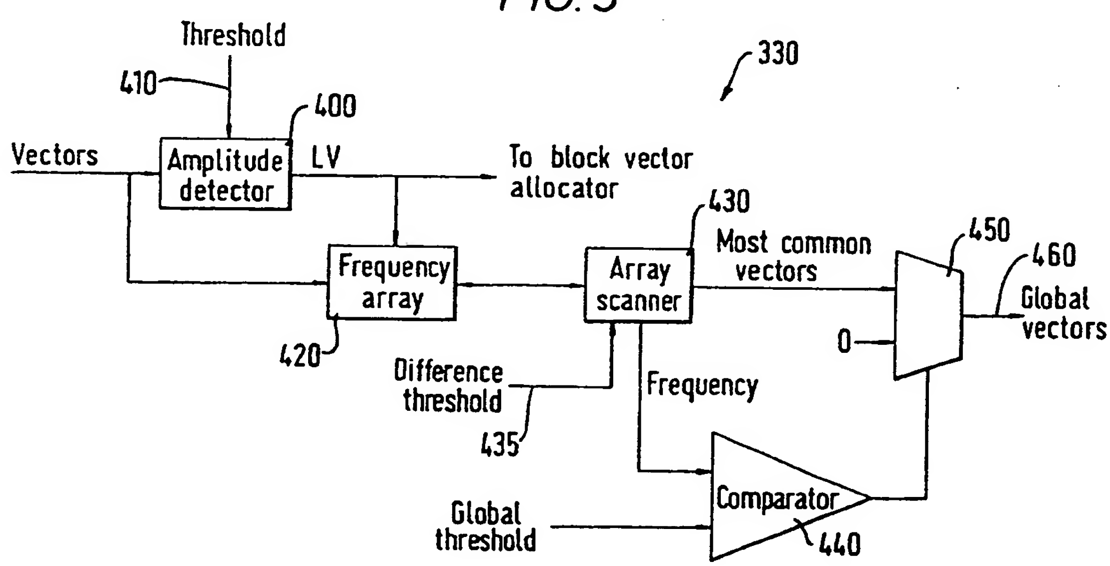
(56) Documents Cited
GB 2263600 A

(58) Field of Search
UK CL (Edition L) H4F FGM
INT CL^5 G06F 15/70, H04N 5/14

(54) **Detecting motion vectors in video signal processing; comparison with threshold.**

(57) Motion compensated video signal processing apparatus comprises means (190, 200, 210 Fig. 1) for generating a plurality of motion vectors to represent image motion between a pair of input images of an input video signal, for use in interpolation of an output image of an output video signal; means 400 for detecting whether each motion vector is greater than a predetermined size; and means 450 for restricting the use, in interpolation of the output image, of a motion vector detected to be greater than the predetermined size. Such motion vectors may be prevented 450 from use as global motion vectors.

FIG. 3



GB 2 277 005 A

1/5

FIG. 1

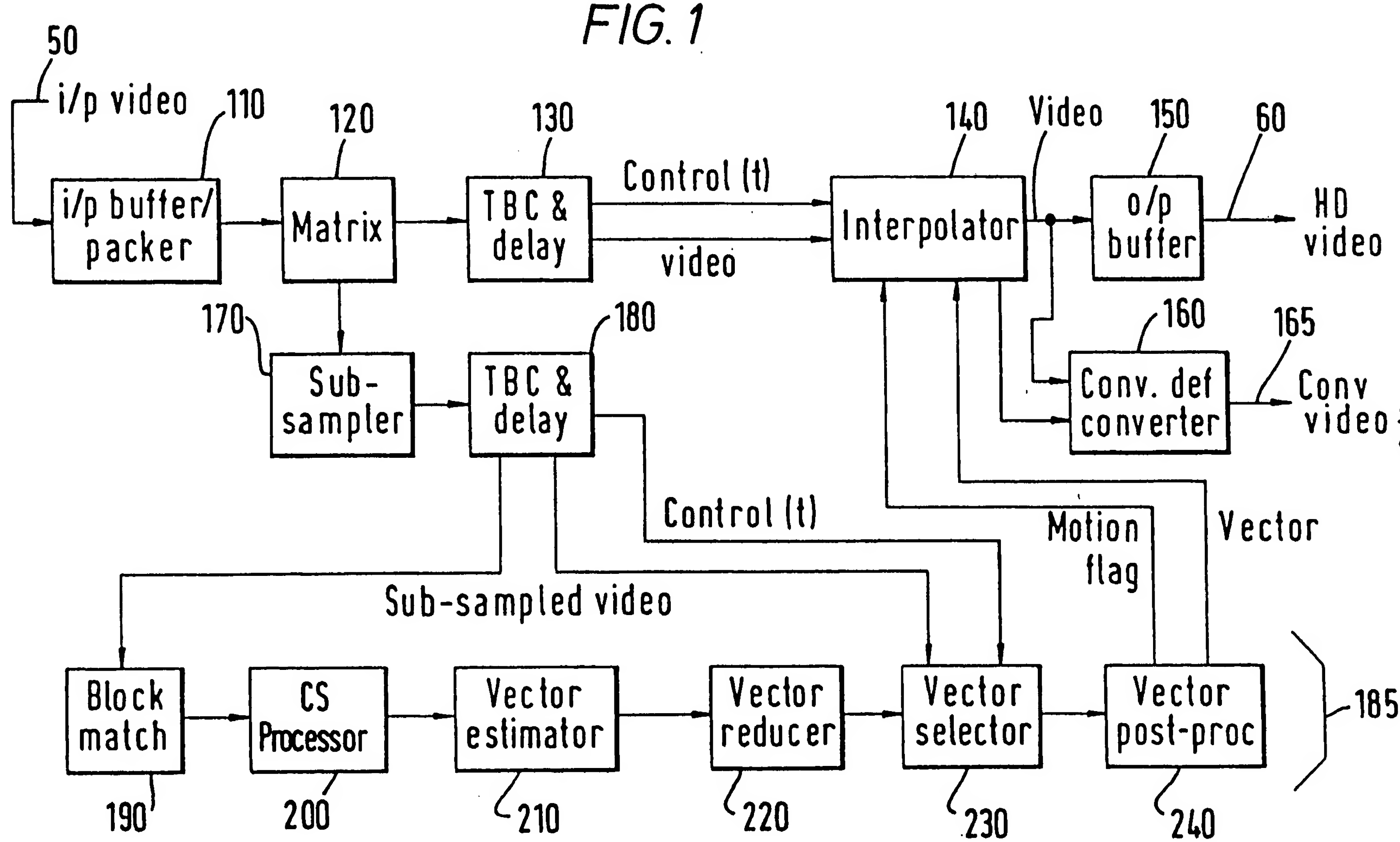

50
i/p video
110
i/p buffer/ packer
120
Matrix
130
TBC & delay
Control (t)
video
140
Interpolator
Video
150
o/p buffer
60
HD video
170
Sub-sampler
180
TBC & delay
160
Conv. def converter
165
Conv video
Control (t)
Motion flag
Vector
Sub-sampled video
Block match
190
CS Processor
200
Vector estimator
210
Vector reducer
220
Vector selector
230
Vector post-proc
240
185

FIG. 2

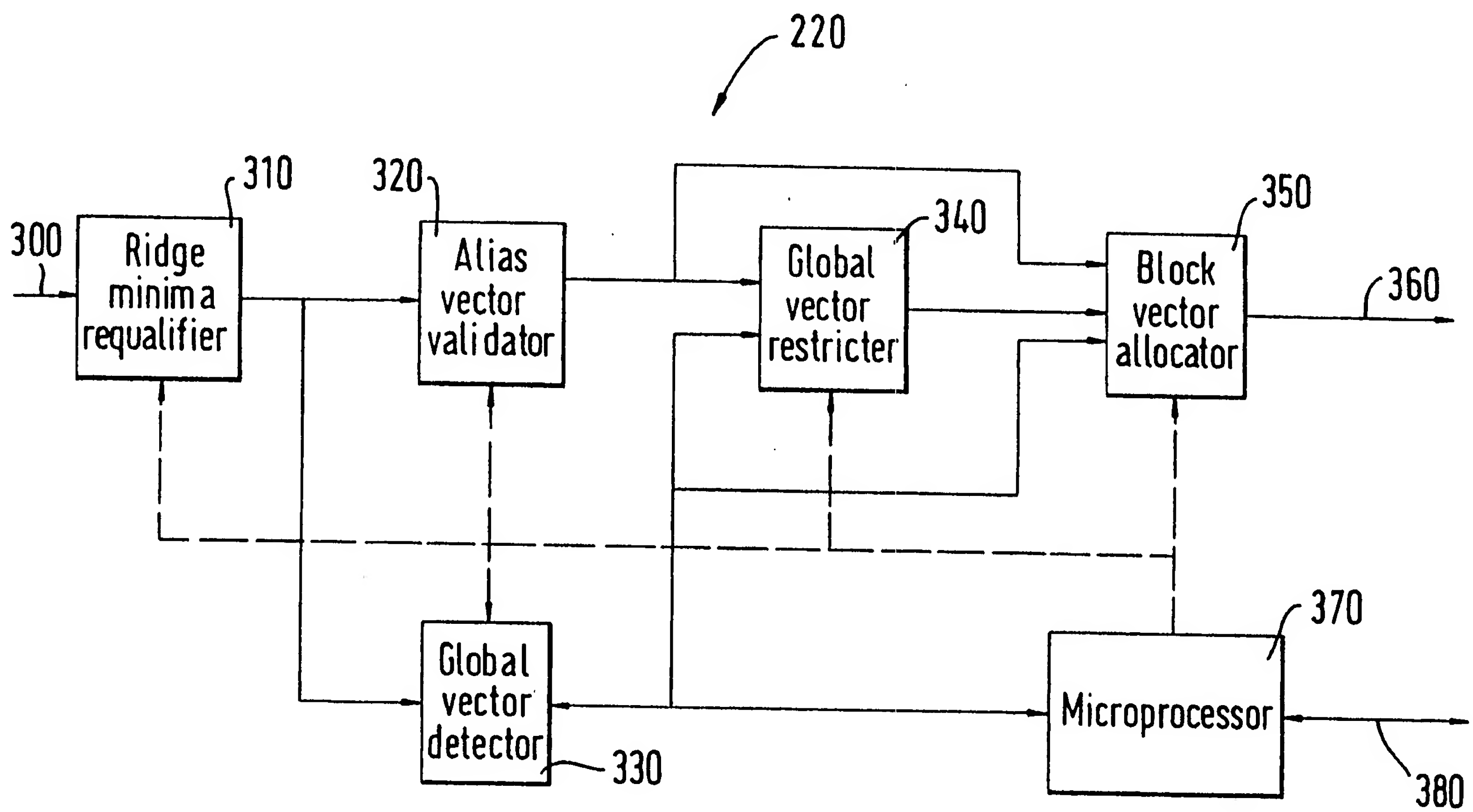
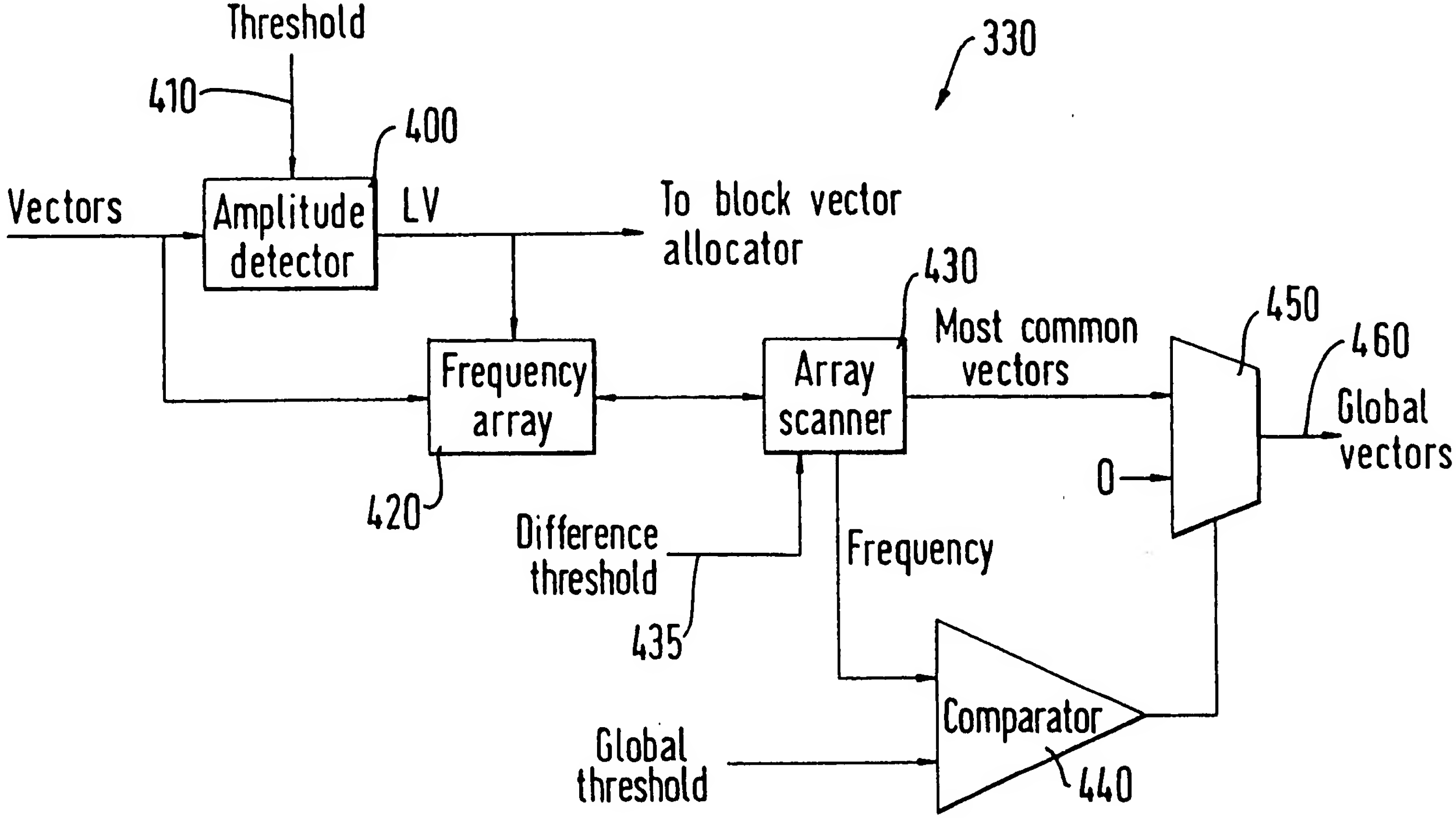

220
300
Ridge minima requalifier
310
320
Alias vector validator
Global vector detector
330
Global vector restricter
340
Block vector allocator
350
360
Microprocessor
370
380

FIG. 3


330
Threshold
410
400
Vectors
Amplitude detector
LV
To block vector allocator
Frequency array
420
Array scanner
430
Difference threshold
435
Most common vectors
Frequency
Comparator
440
Global threshold
0
450
460
Global vectors

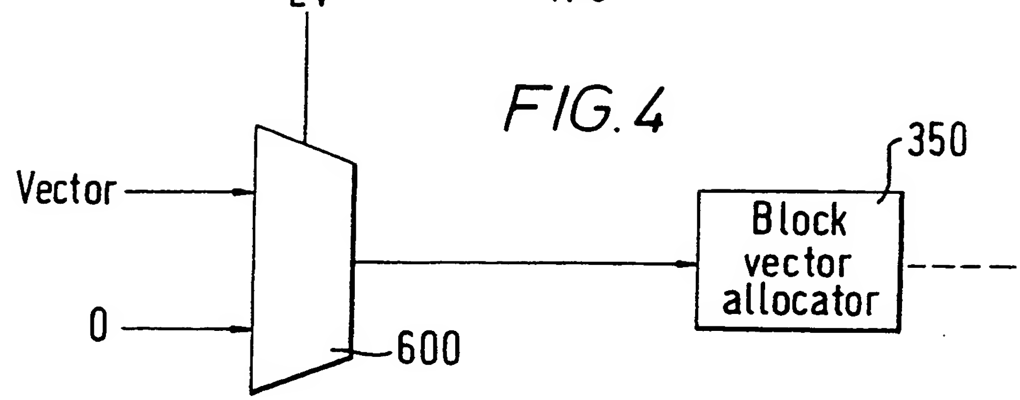


FIG. 4

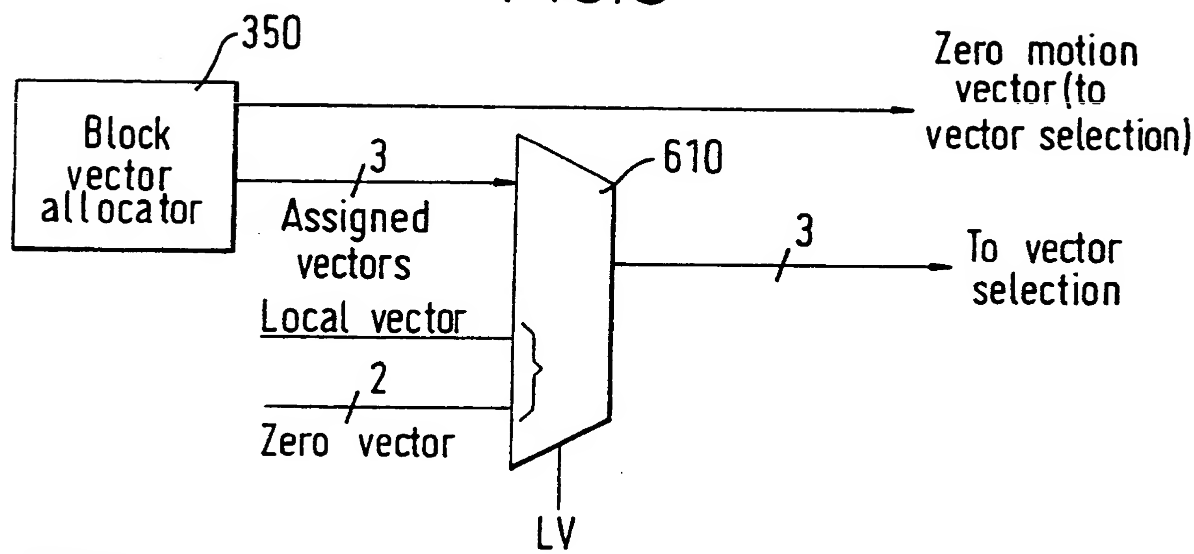


FIG. 5

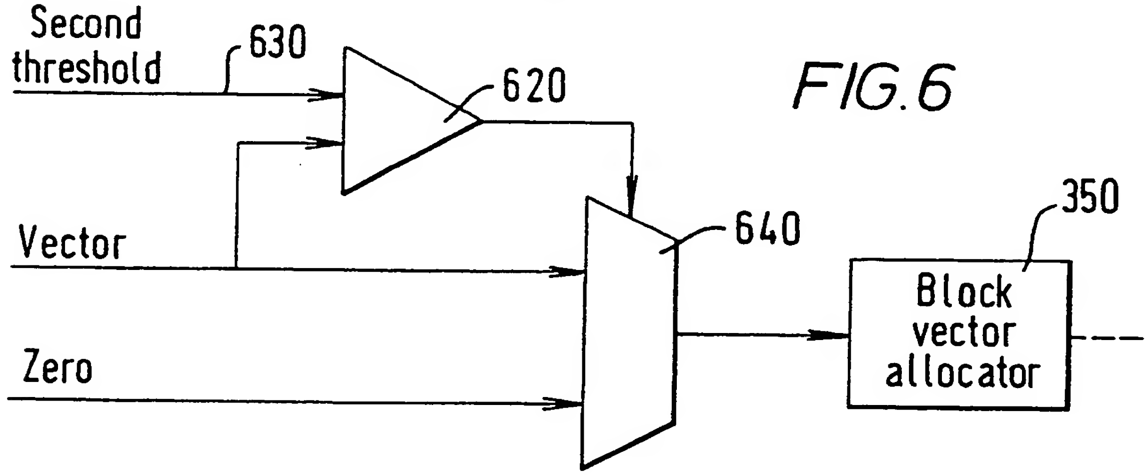
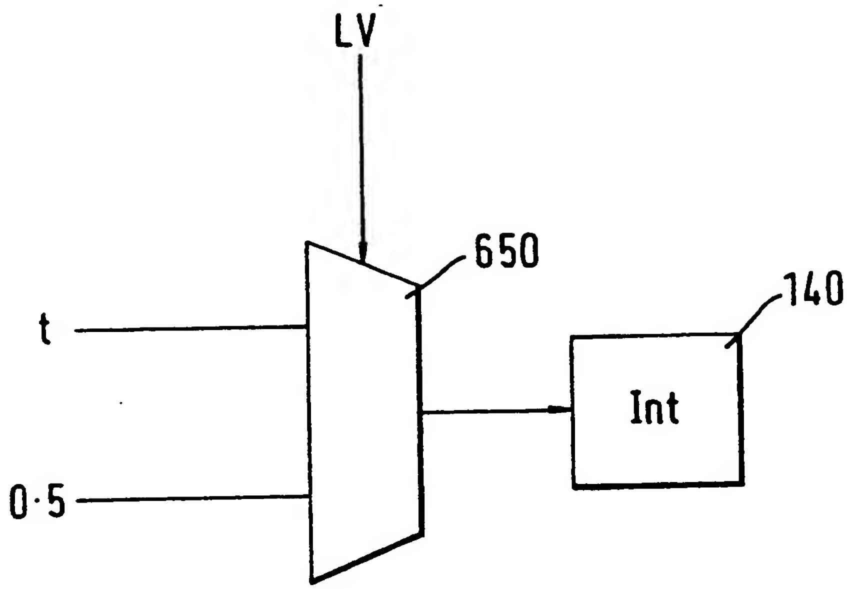


FIG. 6

FIG. 7



2277005

MOTION COMPENSATED VIDEO SIGNAL PROCESSING

This invention relates to motion compensated video signal processing.

Motion compensated video signal processing is used in applications such as television standards conversion, film standards conversion and conversion between video and film standards.

In a motion compensated television standards converter, such as the converter described in UK patent application number GB-A-2 231 749, pairs of successive input images are processed to generate sets of motion vectors representing image motion between the pair of input images. The processing is carried out on discrete blocks of the images, so that each motion vector represents the inter-image motion of the content of a respective block.

In the motion vector estimation process a correlation surface representing spatial correlation between blocks of the two input images is examined to detect points of maximum correlation. (The correlation surface actually represents the difference between the two input images so that the points of maximum correlation are in fact minima on the correlation surface, and will be referred to as such herein.) When a minimum has been detected, a motion vector is generated from the spatial position of the minimum in the correlation surface. Tests are performed to determine whether that minimum represents a significant peak in correlation with respect to the remainder of the correlation surface. If the minimum passes this test it is treated as being "valid", and a confidence flag associated with the motion vector is set.

After the individual motion vectors, termed "local" motion vectors, have been derived for the blocks of the input image, the local motion vectors are supplied to a motion vector reducer. The motion vector reducer assigns to each block a set of motion vectors selected, in order of preference, from: the zero motion vector; the local motion vector for that block; the local motion vectors for blocks neighbouring that block in the input image; and a set of vectors known as "global" motion vectors. The global motion vectors are derived for each image by ranking all the (valid) local motion vectors for this image in order of decreasing frequency, and then selecting from the most common of the

local motion vectors a number of unique motion vectors to be used as global motion vectors. A constraint is applied here to ensure that the global motion vectors differ from each other by at least a minimum amount.

The sets of motion vectors for all the blocks of the input image are then supplied to a motion vector selector. The purpose of the motion vector selector is to allocate to each picture element (pixel) of a block of an output image a single motion vector selected from the set of motion vectors supplied for a corresponding block of the input image. As this motion vector will be used in interpolation of the output pixel, the set of motion vectors supplied to the motion vector selector are tested, by performing a correlation test on blocks of pixels pointed to by each of the set of motion vectors, so that the "best" motion vector is selected for each pixel from the set of motion vectors for the corresponding block. The selected motion vector for each pixel is then supplied to a motion compensated interpolator which uses these motion vectors to interpolate the pixels of an output image from the pair of input images in dependence upon the temporal offset of the output image from the pair of input images.

The purpose of the motion vector reducer is therefore to provide the motion vector selector with a reasonable selection of motion vectors for each block from which to select the most appropriate motion vector for each output pixel corresponding to that block. The global motion vectors each represent a motion which was frequently detected in the image as a whole, so that it is often reasonable to include these vectors in the sets of vectors from which the most appropriate vectors are selected by the motion vector selector.

It has been observed that rapidly moving portions of a video image have a lower spatial detail than stationary or slowly moving portions. This means that even if a motion vector can be estimated which accurately represents the rapid motion of the object, the correlation test performed during vector selection (which relies on detecting correlation between parts of the same object in two successive input fields) can be unreliable.

This invention provides a motion compensated video signal processing apparatus comprising:

means for generating a plurality of motion vectors to represent

image motion between a pair of input images of an input video signal, for use in interpolation of an output image of an output video signal;

means for detecting whether each motion vector is greater than a predetermined size; and

means for restricting the use, in interpolation of the output image, of a motion vector detected to be greater than the predetermined size.

Accordingly, even though large magnitude (long) motion vectors (i.e. vectors representing rapid image motion) can be generated, these large vectors are deliberately restricted in their use in interpolation of the output image. This is because the lack of spatial detail in fast-moving objects (e.g. due to camera integration blur) means that:

a) the vector selection process applied to rapidly moving objects can be unreliable, and

b) for rapidly moving objects, the eye is less able to detect the judder introduced by non motion compensated interpolation; this judder can therefore be less subjectively disturbing than motion compensated interpolation using erroneously selected vectors.

In one preferred embodiment each motion vector comprises a plurality of coordinate values representing image motion along respective coordinate axes; and the means for detecting comprises means for comparing each of the coordinate values with a respective predetermined threshold value associated with each of the coordinate axes.

In another preferred embodiment each motion vector again comprises a plurality of coordinate values representing image motion along respective coordinate axes; and the means for detecting comprises means for generating a magnitude value from the coordinate values for each motion vector, the magnitude value representing the magnitude of the image motion represented by that motion vector, and means for comparing the magnitude value with a predetermined threshold value. In this case, it is preferred that the means for generating a magnitude value is operable to detect the square root of a weighted sum of the squares of the coordinate values. A weighted sum may be used to reflect a different scaling of motion vector coordinate values in the various coordinate directions. Alternatively, the weighting could be applied equally to the individual squared coordinate values.

Although the coordinate axes could lie along various directions with respect to the input images, it is preferred that the coordinate axes represent vertical and horizontal image motion.

Preferably each motion vector represents image motion of a respective block of one input image of the pair between that image and the other image of the pair, and the apparatus comprises: means for deriving a set of global motion vectors comprising a plurality of distinct motion vectors selected from the most common of the plurality of motion vectors; and means for assigning to each of the blocks a group of motion vectors selected from the zero motion vector, the motion vector representing image motion of that block and the global motion vectors.

In order to prevent global vectors being selected which only represent the motion of a small part of the image, it is preferred that each motion vector selected as a global vector has at least a predetermined number of occurrences among the plurality of motion vectors.

In one embodiment the "long" motion vectors can be prevented from being used as a global motion vector. To this end, it is preferred that the means for restricting comprises means for preventing selection as a global motion vector of a motion vector detected to be greater than the predetermined size.

In another embodiment, the use of the "long" motion vector can be further restricted, by employing a means for restricting comprising means, responsive to a detection that the motion vector representing motion of a block is greater than the predetermined size, for controlling the means for assigning to assign to that block only the zero motion vector and the motion vector representing motion of that block.

In a further preferred embodiment, the "long" motion vectors can be completely discarded, by employing a means for restricting comprising means for preventing the use, in interpolation of an output image, of a motion vector detected to be greater than the predetermined size.

In order that different measures can be taken for motion vectors in two different size ranges, it is preferred that the apparatus comprises: means for detecting whether each motion vector is greater

than a second predetermined size, the second predetermined size being greater than the firstmentioned predetermined size; and means for preventing the use, in interpolation of the output image, of a motion vector detected to be greater than the second predetermined size.

In another preferred embodiment the means for restricting comprises means for setting a flag, associated with each motion vector, to indicate whether that motion vector is greater than the predetermined size, and the apparatus comprises: means for selecting a motion vector, from the plurality of motion vectors, for use in interpolation of each pixel of the output image; a motion compensated pixel interpolator operable according to at least two modes of operation; and means for selecting one of the modes of operation of the motion compensated pixel interpolator, for interpolation of a pixel of the output image, in dependence on whether the flag, corresponding to the motion vector selected for use in interpolation of that pixel, is set. In this way, the interpolation operation can be matched to the motion characteristics of the video signal.

Although various arrangements of the pixel interpolator can be employed to give different interpolation operations in dependence on whether the flag is set, it is preferred that the pixel interpolator is operable, according to one of the modes of operation, to interpolate between blocks of each of the two images, pointed to by the selected motion vector, according to a combining ratio dependent upon the temporal position of the output image with respect to the pair of input images; and the pixel interpolator is operable, according to another mode of operation, to interpolate between blocks of each of the two images, pointed to by the zero motion vector, according to an equal combining ratio.

As mentioned above, a problem can arise when the global vectors are derived from a relatively small number of occurrences. For example, if the majority of the image is stationary, except for a small moving object, the majority of the motion vectors for that image would be close to zero. The vectors representing the stationary parts of the image may differ slightly due to noise or aliasing, but would still be too close to one another to be selected individually as global vectors. The next most commonly occurring vector, which would therefore be selected as a global vector, would be the vector derived from the small

moving object. If this vector is passed to vector selection as one of the four vectors associated with a non-moving block of the image, it may be spuriously selected during vector selection. The use of a grossly incorrect vector in this way can result in visible artifacts being generated.

Viewed from a second aspect this invention provides a motion compensated video signal processing apparatus in which motion vectors are generated to represent image motion between a pair of input images of an input video signal, the apparatus comprising:

means for generating a plurality of local motion vectors to represent image motion of respective blocks of one input image of the pair between that image and the other image of the pair;

means for deriving from the local motion vectors a set of global motion vectors comprising a plurality of distinct motion vectors selected from the most common of the local motion vectors, each global vector having at least a predetermined number of occurrences among the local motion vectors; and

means for assigning to each of the blocks a group of motion vectors selected from the zero motion vector, the local motion vector for that block and the global motion vectors.

This aspect of the invention addresses the problem of using global motion vectors derived from a relatively small number of occurrences, by preventing the selection as a global motion vector of a local vector which occurs fewer than a predetermined number of times.

Preferably the means for deriving comprises means for preventing the selection, as global motion vectors, of two or more local motion vectors which differ from one another by less than a predetermined amount.

In a preferred embodiment, the predetermined number of occurrences can be adjusted under the control of an operator.

In an advantageously simple embodiment the apparatus comprises means for storing a frequency array comprising a plurality of addressable memory locations, each possible value of the motion vectors representing the address of a respective memory location; means for incrementing a frequency value stored at the memory location corresponding to each of the plurality of motion vectors; and means for detecting those memory locations having the highest stored frequency

values.

Apparatus according to the invention is particularly usefully employed in a television standards conversion apparatus.

Viewed from a third aspect this invention provides a method of motion compensated video signal processing, the method comprising the steps of:

generating a plurality of motion vectors to represent image motion between a pair of input images of an input video signal, for use in interpolation of an output image of an output video signal;

detecting whether each motion vector is greater than a predetermined size; and

restricting the use, in interpolation of the output image, of a motion vector detected to be greater than the predetermined size.

Viewed from a fourth aspect this invention provides a method of motion compensated video signal processing in which motion vectors are generated to represent image motion between a pair of input images of an input video signal, the method comprising the steps of:

generating a plurality of local motion vectors to represent image motion of respective blocks of one input image of the pair between that image and the other image of the pair;

deriving from the local motion vectors a set of global motion vectors comprising a plurality of distinct motion vectors selected from the most common of the local motion vectors, each global vector having at least a predetermined number of occurrences among the local motion vectors; and

assigning to each of the blocks a group of motion vectors selected from the zero motion vector, the local motion vector for that block and the global motion vectors.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a schematic block diagram of a motion compensated television standards conversion apparatus;

Figure 2 is a schematic block diagram of a motion vector reducer;

Figure 3 is a schematic block diagram of a global vector detector; and

Figures 4 to 7 show modifications to the apparatus of Figure 1 to

control the use of motion vectors in response to a long vector flag.

Figure 1 is a schematic block diagram of a motion compensated television standards conversion apparatus. The apparatus receives an input interlaced digital video signal 50 (e.g. an 1125/60 2:1 high definition video signal (HDVS)) and generates an output interlaced digital video signal 60 (e.g a 1250/50 2:1 signal).

The input video signal 50 is first supplied to an input buffer/packer 110. In the case of a conventional definition input signal, the input buffer/packer 110 formats the image data into a high definition (16:9 aspect ratio) format, padding with black pixels where necessary. For a HDVS input the input buffer/packer 110 merely provides buffering of the data.

The data are passed from the input buffer/packer 110 to a matrix circuit 120 in which (if necessary) the input video signal's colorimetry is converted to the standard "CCIR recommendation 601" (Y,Cr,Cb) colorimetry.

From the matrix circuit 120 the input video signal is passed to a time base changer and delay 130, and via a sub-sampler 170 to a subsampled time base changer and delay 180. The time base changer and delay 130 determines the temporal position of each field of the output video signal, and selects the two fields of the input video signal which are temporally closest to that output field for use in interpolating that output field. For each field of the output video signal, the two input fields selected by the time base changer are appropriately delayed before being supplied to an interpolator 140 in which that output field is interpolated. A control signal t, indicating the temporal position of each output field with respect to the two selected input fields, is supplied from the time base changer and delay 130 to the interpolator 140.

The subsampled time base changer and delay 180 operates in a similar manner, but using spatially subsampled video supplied by the subsampler 170. Pairs of fields, corresponding to the pairs selected by the time base changer 130, are selected by the subsampled time base changer and delay 180 from the subsampled video, to be used in the generation of motion vectors.

The time base changers 130 and 180 can operate according to synchronisation signals associated with the input video signal, the

output video signal, or both. In the case in which only one synchronisation signal is supplied, the timing of fields of the other of the two video signals is generated deterministically within the time base changers 130, 180.

The pairs of fields of the subsampled input video signal selected by the subsampled time base changer and delay 180 are supplied to a motion processor 185 comprising a direct block matcher 190, a correlation surface processor 200, a motion vector estimator 210, a motion vector reducer 220, a motion vector selector 230 and a motion vector post-processor 240. The pairs of input fields are supplied first to the direct block matcher 190 which calculates correlation surfaces representing the spatial correlation between search blocks in the temporally earlier of the two selected input fields and (larger) search areas in the temporally later of the two input fields.

From the correlation surfaces output by the block matcher 190, the correlation surface processor 200 generates a larger number of interpolated correlation surfaces, which are then passed to the motion vector estimator 210. The motion vector estimator 210 detects points of greatest correlation in the interpolated correlation surfaces. (The original correlation surfaces actually represent the difference between blocks of the two input fields; this means that the points of maximum correlation are in fact minima on the correlation surfaces, and are referred to as "minima"). In order to detect a minimum, additional points on the correlation surfaces are interpolated, providing a degree of compensation for the loss of resolution caused by the use of subsampled video to generate the surfaces. From the detected minimum on each correlation surface, the motion vector estimator 210 generates a motion vector which is supplied to the motion vector reducer 220.

The motion vector estimator 210 also performs a confidence test on each generated motion vector to establish whether that motion vector is significant above the average data level, and associates a confidence flag with each motion vector indicative of the result of the confidence test. The confidence test, known as the "threshold" test, is described (along with certain other features of the apparatus of Figure 1) in GB-A-2 231 749 and British Patent Application number 9307442.5.

A test is also performed by the motion vector estimator 210 to

detect whether each vector is aliased. In this test, the correlation surface (apart from an exclusion zone around the detected minimum) is examined to detect the next lowest minimum. If this second minimum does not lie at the edge of the exclusion zone, the motion vector derived from the original minimum is flagged as being potentially aliased.

The motion vector reducer 220 operates to reduce the choice of possible motion vectors for each pixel of the output field, before the motion vectors are supplied to the motion vector selector 230. The output field is notionally divided into blocks of pixels, each block having a corresponding position in the output field to that of a search block in the earlier of the selected input fields. The motion vector reducer compiles a group of four motion vectors to be associated with each block of the output field, with each pixel in that block eventually being interpolated using a selected one of that group of four motion vectors.

Vectors which have been flagged as "aliased" are re-qualified during vector reduction if they are identical, or similar within a selectable threshold, to non-flagged vectors in nearby blocks.

As part of its function, the motion vector reducer 220 counts the frequencies of occurrence of "good" motion vectors (i.e. motion vectors which pass the confidence test and the alias test, or which were re-qualified as non-aliased), with no account taken of the position of the blocks of the input fields used to obtain those motion vectors. The good motion vectors are then ranked in order of decreasing frequency. The most common of the good motion vectors which are significantly different to one another are then classed as "global" motion vectors. Three motion vectors which pass the confidence test are then selected for each block of output pixels and are supplied, with the zero motion vector, to the motion vector selector 230 for further processing. These three selected motion vectors are selected in a predetermined order of preference from:

(i) the motion vector generated from the corresponding search block (the "local" motion vector);

(ii) those generated from surrounding search blocks ("neighbouring" motion vectors); and

(iii) the global motion vectors.

The motion vector selector 230 also receives as inputs the two input fields which were selected by the subsampled time base changer and delay 180 and which were used to calculate the motion vectors, along with the control signal t. These fields are suitably delayed so that they are supplied to the motion vector selector 230 at the same time as the vectors derived from them. The motion vector selector 230 supplies an output comprising one motion vector per pixel of the output field. This motion vector is selected from the four motion vectors for that block supplied by the motion vector reducer 220.

The vector selection process involves detecting the degree of correlation between test blocks of the two input fields pointed to by a motion vector under test. The motion vector having the greatest degree of correlation between the test blocks is selected for use in interpolation of the output pixel. A "motion flag" is also generated by the vector selector. This flag is set to "static" (no motion) if the degree of correlation between blocks pointed to by the zero motion vector is greater than a preset threshold.

The vector post-processor reformats the motion vectors selected by the motion vector selector 230 to reflect any vertical or horizontal scaling of the picture, and supplies the reformatted vectors to the interpolator 140. Using the motion vectors, the interpolator 140 interpolates an output field from the corresponding two (non-subsampled) interlaced input fields selected by the time base changer and delay 130, taking into account any image motion indicated by the motion vectors currently supplied to the interpolator 140.

If the motion flag indicates that the current output pixel lies in a moving part of the image, pixels from the two selected fields supplied to the interpolator are combined in relative proportions depending on the temporal position of the output field with respect to the two input fields (as indicated by the control signal t), so that a larger proportion of the nearer input field is used. If the motion flag is set to "static" then the temporal weighting is fixed at 50% of each input field. The output of the interpolator 140 is passed to an output buffer 150 for output as a high definition output signal, and to a down-converter 160 which generates a conventional definition output signal 165, using the motion flag.

The down-converter 160 allows a representation of the output of

the apparatus (which may be, for example, a high definition video signal) to be monitored, transmitted and/or recorded using conventional definition apparatus. This has benefits because conventional definition recording equipment is significantly cheaper and very much more widespread than high definition equipment. For example, a simultaneous output of conventional and high definition video may be required for respective transmission by terrestrial and satellite channels. Furthermore, if the output video signal is recorded directly onto film using, for example, an electron beam recorder, the down-converter allows a simultaneous recording to be made onto video tape.

The subsampler 170 performs horizontal and vertical spatial subsampling of the input video fields received from the matrix 120, before those input fields are supplied to the time base changer 180. Horizontal subsampling is a straightforward operation in that the input fields are first prefiltered by a half-bandwidth low pass filter (in the present case of 2:1 horizontal decimation) and alternate video samples along each video line are then discarded, thereby reducing by one half the number of samples along each video line.

Vertical subsampling of the input fields is complicated by the fact that the input video signal 50 is interlaced. This means that successive lines of video samples in each interlaced field are effectively two video lines apart, and that the lines in each field are vertically displaced from those in the preceding or following field by one video line of the complete frame.

The construction and operation of the motion vector reducer 220 will now be described in more detail.

A block diagram of the motion vector reducer 220 is shown in Figure 2. The motion vectors, and their associated flags, derived by the motion vector estimator 210 are supplied via an input 300 of the motion vector reducer 220 to a ridge minima requalifier 310. The ridge minima requalifier 310 "repairs" motion vectors derived from elongate ("ridge") minima, by detecting whether another motion vector along the ridge direction has a matching coordinate at 90° to the ridge direction; if so, then that coordinate is assigned to the ridge vector and a "ridge flag" associated with that vector is reset. The ridge minima requalifier then supplies the vectors, and associated flags, to an alias vector validator 320 and a global vector detector 330. The alias

vector validator 320 performs a test to check whether vectors indicated as potentially aliased can be justifiably requalified as non-aliased, and the vectors, and resulting associated flags, form one input to a global vector restricter 340. The global vector detector 330 derives a set of global motion vectors from the vectors supplied thereto. The global vectors output by the global vector detector 330 form a second input to the global vector restricter 340.

The global vector restricter 340 generates, for each global vector supplied thereto, a global mask array indicating an association between the global vector and various blocks of the input image to which the local vectors supplied from the alias vector validator 320 correspond. The global mask arrays generated by the global vector restricter 340 are supplied to a block vector allocator 350 which also receives the (suitably delayed) local vectors, and associated flags, from the alias vector validator 320 and the global vectors from the global vector detector 330. The block vector allocator 350 assigns to each block of the input image to which the local vectors correspond a plurality of unique vectors which are then supplied via an output 360 of the motion vector reducer 220 to the motion vector selector 230.

The ridge minima requalifier 310, alias vector validator 320, global vector detector 330, global vector restricter 340 and block vector allocator 350 operate under the control (indicated schematically by dotted lines in the figure) of a microprocessor 370. The microprocessor 370 is also connected to the global vector detector 330 to provide for optional manual intervention in the global vector detection process to adjust various parameters. The adjusted parameters can be entered by an operator and supplied by the microprocessor 370 to the global vector detector 330. A two-way communication link 380 is also provided to connect the microprocessor 370 to a further, similar microprocessor (not shown). This is because the entire motion processor (indicated generally as 185 in Figure 1) may in fact be duplicated, the two motion processors performing the processing for alternate output fields. Thus, the vector reducer shown in Figure 2 may be duplicated, and the link 380 is provided for communication of the two microprocessors controlling the vector reduction operation.

The construction and operation of certain components of the

motion vector reducer 220 will now be described in more detail.

The vectors, and flags, output by the ridge minima requalifier 310 are supplied to the global vector detector 330. The purpose of the global vector detector is to derive from the vectors supplied thereto a set of global motion vectors comprising a plurality of unique motion vectors selected from the most common of the local motion vectors. In general terms, the global vector detector 330 ranks local motion vectors corresponding to a given input image in order of decreasing frequency, and selects the eight (in this example) most common vectors as global vectors. However, it can be advantageous to apply various constraints to the process for selecting global vectors from the set of local vectors. In particular, even though large magnitude (long) motion vectors (ie vectors representing rapid image motion) can be generated, it is desirable to prevent such long vectors from contributing to the global vectors. This is because the lack of spatial detail in fast-moving objects (eg due to camera integration blur) means that the operation of the motion vector selector 230 (Figure 1) for rapidly moving objects can be unreliable. It has been observed that rapidly moving portions of a video image have lower spatial detail than stationary or slowly moving portions. This means that even if a motion vector can be estimated which accurately represents the rapid motion of the object, the correlation test performed in the vector selector 230, which relies on detecting correlation between parts of the same object in two successive input fields, can be unreliable. It is therefore preferable to prevent such long vectors from being selected as global vectors to ensure that a large magnitude global vector cannot be incorrectly selected for interpolation of image areas where there is in fact only very small motion. This could produce subjectively disturbing effects in the output image.

A further constraint which is applied to the global vector detection process is to prevent a vector being accepted as a global vector unless it occurs at least a predetermined number of times over the input image as a whole. If a local motion vector is not sufficiently common, and thus represents motion of only a very small part of the image, it is preferable to eliminate the possibility of this vector being assigned to other parts of the image during the

global vector detection stage.

A schematic block diagram of a global vector detector 330 in which the above constraints are implemented is shown in Figure 3. The input vectors, and associated flags, are supplied to an amplitude detector 400 which compares the amplitude, ie magnitude, of each input vector with a predetermined magnitude threshold 410 to decide whether the vector qualifies as a "long" vector. The magnitude threshold 410 may comprise a threshold for both the horizontal and vertical components of a motion vector. For example, the threshold may be set at half the maximum possible range, horizontally and vertically, of a motion vector. In this example, the maximum horizontal range of a motion vector is ±64 pixels, and the maximum vertical range ±32 pixels. Thus, the magnitude threshold 410 may be set at ±32 pixels horizontally and ±16 pixels vertically. If the magnitude of an input vector exceeds the magnitude threshold 410, the amplitude detector 400 sets a "long vector" flag (LV).

As an alternative, the threshold 410 could represent the maximum value of the vector magnitude $\sqrt{(x^2 + y^2)}$, or a weighted sum to reflect a different scaling of the horizontal and vertical coordinates (e.g. $\sqrt{(4x^2 + y^2)}$ or $\sqrt{(x^2 + 4y^2)}$).

The input vectors supplied to the amplitude detector 400 are also supplied to a frequency array 420. Each entry in the frequency array 420 is uniquely addressed by a possible value of the local motion vectors. In this way, a local motion vector generated from the current pair of input fields is used to address the array and to increment the array entry corresponding to the value of the motion vector. However, the long vector flags LV derived by the amplitude detector 400 are also supplied to the frequency array 420. If the long vector flag LV for a motion vector supplied to the frequency array 420 is set, then this prevents the associated motion vector from incrementing the frequency array.

After all the vectors (apart from long vectors) have been counted in this way by the frequency array 420, an array scanner 430 scans the frequency array 420 and identifies the eight array entries which show the highest count, for which the motion vectors differ from each other by at least a predetermined difference threshold 435. The addresses of these array entries represent the values of the eight most common local

vectors (apart from long vectors) for the corresponding pair of input images. The value of the count held by the frequency array for each of these eight vectors (that is, the frequency of occurrence of the vectors) is supplied by the array scanner 430 to a comparator 440 at the same time as the corresponding vector is supplied to an input of a switch 450. The comparator 440 compares the count, or frequency of occurrence, corresponding to each vector with a predetermined threshold number or "global threshold", and provided the count exceeds the global threshold, the corresponding vector will be supplied to the output 460 of the switch 450 as a global motion vector. (A suitable value for the global threshold may vary depending on the particular image material being processed. By way of example, however, the global threshold may be set at 0.5% of the total number of local motion vectors derived from an input image.) If the count corresponding to any of the eight most common vectors does not exceed the global threshold, indicating that the vector does not occur sufficiently frequently to qualify as a global vector, then the comparator 440 generates an output to control the switch 450 such that the corresponding vector is not passed to its output 460 as a global vector, but is replaced by the zero motion vector. Assuming, however, that all eight of the most common vectors pass the global threshold test, then a set of eight unique global motion vectors will be supplied to the output 460 of the switch 450.

It will be appreciated that various further constraints could be applied in the global vector detector 330. In particular, any input local motion vectors for which the corresponding ridge or alias flags are set, or for which the confidence flag indicates that the vector failed the confidence test, may be prevented from contributing to the global vectors in a similar manner to long vectors, ie by preventing such vectors from incrementing the frequency array 420.

As indicated in Figure 3, the long vector flag LV derived for each of the input local motion vectors is supplied by the global vector detector 330, after an appropriate delay, to the block vector allocator 350 (Figure 2) for use in the subsequent vector reduction processing of the local vectors.

As shown in Figure 2, the global vector detector 330 is connected for communication with the microprocessor 370. This allows for the various thresholds used during global vector detection to be modified,

if required, through manual intervention by an operator. The operator can enter new parameters, for example via a system controller (not shown), which are then supplied via the microprocessor 370 to the global vector detector 330.

The global vectors output by the global vector detector 330 are supplied to one input of the global vector restricter 340. At its other input, the global vector restricter 340 receives the processed local motion vectors and associated flags from the alias vector validator 320. The purpose of the global vector restricter 340 is to associate each of the global vectors with blocks of the input image at or near areas where motion identical or similar to that represented by the global motion vector was originally derived. This association will then be used by the block vector allocator 350 to prevent inappropriate global vectors being assigned to blocks, that is, to prevent a block from one area of the input image being assigned a global vector representing significantly different motion of a block in a remote part of the image.

The block vector allocator receives the LV flag from the amplitude detector 400, and can respond in a number of ways. In the embodiment described above, long vectors are already prevented from being used as global vectors; however, the block vector allocator 350 could in fact use the flag to prevent the use of long vectors at all. Such an arrangement is illustrated schematically in Figure 4, in which the LV flag associated with each motion vector controls a multiplexer 600 to pass either the associated vector or the zero vector to the input of the block vector allocator 350.

In another arrangement, illustrated schematically in Figure 5, the vector selection process for a particular block is restricted to the possible use of the long local vector for that block or the zero motion vector only. As shown in Figure 5, the LV flag for each block controls a multiplexer 610 to pass (to vector selection) either the three motion vectors assigned to that block during vector reduction or the local motion vector plus two zero motion vectors.

In another embodiment illustrated in Figure 6, a further amplitude detector 620, similar to the amplitude detector 400, is employed to compare each vector with a second, higher threshold value 630. Although the use of long vectors may in general be allowed

(although restricted as described above), the use of vectors which are greater in size than this second threshold is not allowed. This is achieved by the use of a multiplexer 640 which passes each vector to the block vector allocator 350 only if that vector does not exceed the second threshold size 630.

In a further embodiment, the LV flag can be used to control the operation of the interpolator 140. This arrangement is illustrated in Figure 7, in which the LV flag controls a multiplexer 650, causing it to pass either the control signal t or a fixed value of 0.5 to the interpolator 140. This means that the use of temporal weighting (described above) can be inhibited when the LV flag is set. This can reduce disturbing image artifacts such as the visible judder caused by beating effects that may be observed on moving portions of "shuttered" images.

CLAIMS

1. Motion compensated video signal processing apparatus comprising:

means for generating a plurality of motion vectors to represent image motion between a pair of input images of an input video signal, for use in interpolation of an output image of an output video signal;

means for detecting whether each motion vector is greater than a predetermined size; and

means for restricting the use, in interpolation of the output image, of a motion vector detected to be greater than the predetermined size.

2. Apparatus according to claim 1, in which:

each motion vector comprises a plurality of coordinate values representing image motion along respective coordinate axes; and

the means for detecting comprises means for comparing each of the coordinate values with a respective predetermined threshold value associated with each of the coordinate axes.

3. Apparatus according to claim 1, in which:

each motion vector comprises a plurality of coordinate values representing image motion along respective coordinate axes; and

the means for detecting comprises means for generating a magnitude value from the coordinate values for each motion vector, the magnitude value representing the magnitude of the image motion represented by that motion vector, and means for comparing the magnitude value with a predetermined threshold value.

4. Apparatus according to claim 3, in which the means for generating a magnitude value is operable to detect the square root of a weighted sum of the squares of the coordinate values.

5. Apparatus according to any one of claims 2 to 4, in which the coordinate axes represent vertical and horizontal image motion.

6. Apparatus according to any one of the preceding claims, in which each motion vector represents image motion of a respective block of one

input image of the pair between that image and the other image of the pair, the apparatus comprising:

means for deriving a set of global motion vectors comprising a plurality of distinct motion vectors selected from the most common of the plurality of motion vectors; and

means for assigning to each of the blocks a group of motion vectors selected from the zero motion vector, the motion vector representing image motion of that block and the global motion vectors.

7. Apparatus according to claim 6, in which each motion vector selected as a global vector has at least a predetermined number of occurrences among the plurality of motion vectors.

8. Apparatus according to claim 6 or claim 7, in which the means for restricting comprises means for preventing selection as a global motion vector of a motion vector detected to be greater than the predetermined size.

9. Apparatus according to any one of claims 6 to 8, in which the means for restricting comprises means, responsive to a detection that the motion vector representing motion of a block is greater than the predetermined size, for controlling the means for assigning to assign to that block only the zero motion vector and the motion vector representing motion of that block.

10. Apparatus according to any one of claims 1 to 5, in which the means for restricting comprises means for preventing the use, in interpolation of an output image, of a motion vector detected to be greater than the predetermined size.

11. Apparatus according to any one of claims 1 to 5, comprising:

means for detecting whether each motion vector is greater than a second predetermined size, the second predetermined size being greater than the firstmentioned predetermined size; and

means for preventing the use, in interpolation of the output image, of a motion vector detected to be greater than the second predetermined size.

12. Apparatus according to any one of claims 1 to 5, in which the means for restricting comprises means for setting a flag, associated with each motion vector, to indicate whether that motion vector is greater than the predetermined size, the apparatus comprising:

means for selecting a motion vector, from the plurality of motion vectors, for use in interpolation of each pixel of the output image;

a motion compensated pixel interpolator operable according to at least two modes of operation; and

means for selecting one of the modes of operation of the motion compensated pixel interpolator, for interpolation of a pixel of the output image, in dependence on whether the flag, corresponding to the motion vector selected for use in interpolation of that pixel, is set.

13. Apparatus according to claim 12, in which:

the pixel interpolator is operable, according to one of the modes of operation, to interpolate between blocks of each of the two images, pointed to by the selected motion vector, according to a combining ratio dependent upon the temporal position of the output image with respect to the pair of input images; and

the pixel interpolator is operable, according to another mode of operation, to interpolate between blocks of each of the two images, pointed to by the zero motion vector, according to an equal combining ratio.

14. Motion compensated video signal processing apparatus in which motion vectors are generated to represent image motion between a pair of input images of an input video signal, the apparatus comprising:

means for generating a plurality of local motion vectors to represent image motion of respective blocks of one input image of the pair between that image and the other image of the pair;

means for deriving from the local motion vectors a set of global motion vectors comprising a plurality of distinct motion vectors selected from the most common of the local motion vectors, each global vector having at least a predetermined number of occurrences among the local motion vectors; and

means for assigning to each of the blocks a group of motion vectors selected from the zero motion vector, the local motion vector

for that block and the global motion vectors.

15. Apparatus according to claim 14, in which the means for deriving comprises means for preventing the selection, as global motion vectors, of two or more local motion vectors which differ from one another by less than a predetermined amount.

16. Apparatus according to claim 14 or claim 15, in which the predetermined number of occurrences can be adjusted under the control of an operator.

17. Apparatus according to any one of claims 14 to 16, comprising:

means for storing a frequency array comprising a plurality of addressable memory locations, each possible value of the motion vectors representing the address of a respective memory location;

means for incrementing a frequency value stored at the memory location corresponding to each of the plurality of motion vectors; and

means for detecting those memory locations having the highest stored frequency values.

18. Television standards conversion apparatus comprising apparatus according to any one of the preceding claims.

19. A method of motion compensated video signal processing, the method comprising the steps of:

generating a plurality of motion vectors to represent image motion between a pair of input images of an input video signal, for use in interpolation of an output image of an output video signal;

detecting whether each motion vector is greater than a predetermined size; and

restricting the use, in interpolation of the output image, of a motion vector detected to be greater than the predetermined size.

20. A method of motion compensated video signal processing in which motion vectors are generated to represent image motion between a pair of input images of an input video signal, the method comprising the steps of:

generating a plurality of local motion vectors to represent image motion of respective blocks of one input image of the pair between that image and the other image of the pair;

deriving from the local motion vectors a set of global motion vectors comprising a plurality of distinct motion vectors selected from the most common of the local motion vectors, each global vector having at least a predetermined number of occurrences among the local motion vectors; and

assigning to each of the blocks a group of motion vectors selected from the zero motion vector, the local motion vector for that block and the global motion vectors.

21. Motion compensated video signal processing apparatus substantially as hereinbefore described with reference to the accompanying drawings.

22. A method of motion compensated video signal processing, the method being substantially as hereinbefore described with reference to the accompanying drawings.

23. Television standards conversion apparatus substantially as hereinbefore described with reference to the accompanying drawings.

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(ii) Int Cl (Edition 5) H0GN (5/14); G06F (15/70)

Search Examiner

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Databases (see over)

(i) UK Patent Office

(ii)

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Documents considered relevant following a search in respect of claims 1 TO 13, 19

Cat gory (see over)	Identity of document and relevant passages	Relevant to claim(s)
X,E	GB 2263600 A (SONY) 28/07/93 see page 5, see page 5, lines 17-22; page 15, line 34 to page 17, line 20	1, 19

SF2(p)

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Category	Id ntity of document and relevant passages -25-	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

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